ILLUMINATING ENGINEERING

MARCH 1952

Design Data for Mercury Vapor Lamp Circuits
Glare Factors—New Guides to Eye Comfort
Appraisal of Glare on Lighted Streets
Cotton Classing by Artificial Light
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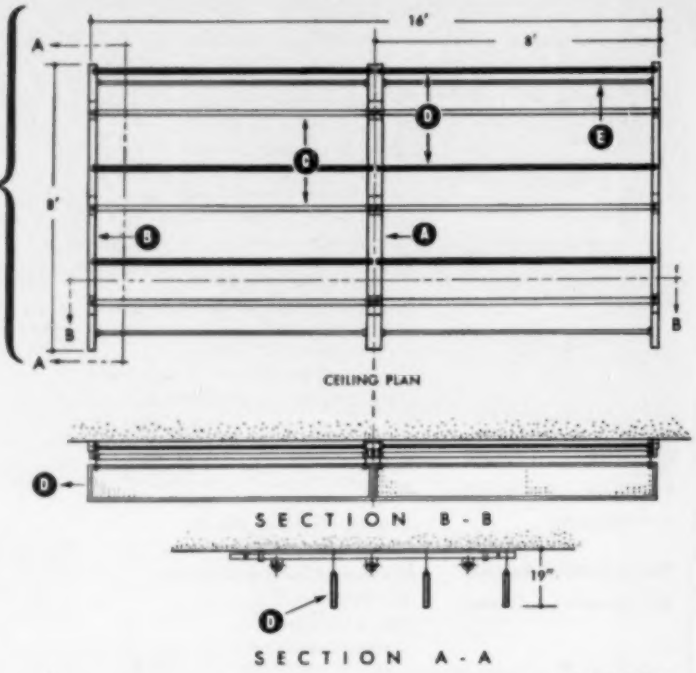

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Glare Factors—

New Guides to Eye Comfort

By GEORGE GILLEARD
WILLIAM WEIBEL

PREDETERMINATION of illumination quality and quantity is vitally important in the satisfactory planning of interior lighting. Methods for determining the quantity of illumination are widely known and used. Methods for determining the quality of illumination have been given a great deal of thought but heretofore, few methods have been put in a form available for general use by lighting people.

This paper is intended to show that the method of glare factors by Harrison[1] and Meaker[2] is practical, easily used and when interpreted correctly, aids in predetermining lighting comfort of an installation. A complete photometric test of a luminaire provides the necessary data. The computation of glare factors is based on these data and the final chart of ratings require no further computations for study or application.

The attainment of higher illumination levels has often been only at the sacrifice of eye comfort, and direct glare has long been recognized as one of the undesirable elements. In 1922 Ward Harrison presented a paper "Light Without Glare" at the Annual Convention of the A.I.E.E. Since that time, there have been fine efforts by the I.E.S. Quality and Quantity Committee, Moon and Spencer, Logan, Guth and others in evaluating glare and specifying conditions for improving quality of lighting. Recently, a fine and complete appraisal of office lighting systems[3] included comparisons of lighting comfort as one of its features.

The luminaire, though naturally a frequent source of direct glare, has often been unjustly accused. Early attempts at glare evaluation were based solely on maximum luminaire brightness. The total area of such brightness was ignored and the effect on the eye of abrupt changes of brightness when viewing adjacent surfaces of luminaire or room were not recognized.

A worthwhile method of comfort evaluation must include many considerations. The luminaire brightnesses, their area and position, and the luminaire location are all basic. The room shape and finishes must be recognized. The task and time elements should be given their proper place. Finally, the method of evaluation must be practical, easily applied, and generally acceptable.

Glare Factors are the new guides to eye comfort. The charts of factors are complete in themselves and can be applied with no further computations. The factors recognize size and brightness of source, position and brightness ratios of surrounding areas. Recent work by Guth and Logan and the Q & Q Committee has indicated that the weights of size, brightness, position, etc. may be different from that employed in the original glare factor work. However, numerous checks have indicated that the differences which may be introduced do not materially alter the conclusions that may be drawn by the use of glare factors. Because there is still hope that the newer knowledge may be applied to glare factors, the present tables are all labeled as "provisional."

A variety of room sizes and mounting heights are included on each glare factor chart so that desirable orientation may be quickly identified. Comparison of charts for several luminaires reveals the more desirable luminaire for a given room.

The design of a practical luminaire for a definite application can be aided by a study of glare factors. The shielding, reflector contour, materials, and finishes all influence the final factors and eye comfort. For example, experience with glare calculations for offices and schools has shown that luminous side panels having an area of about 200 square inches should not exceed approximately 225 footlamberts or one-half candle per square inch in brightness if the resulting glare factor is to be maintained at a desirable value.[4] For this same reason, louvering of at least 35 degrees is advisable.[5]

Glare factors increase in size as less desirable conditions of luminaire and interior are experienced. An installation of well-designed luminaires may have, for example, a glare factor of 10, in a given interior. This is in comparison with a factor of 300 for an installation of diffusing globes providing the same average illumination in an identical interior. This does not mean that the latter is 30 times as glaring, but it will be very definitely more uncomfortable. Experience to date indicates that glare factors of 15 or below are very comfort-

Authors: Curtis Lighting Inc., Chicago, Illinois

TABLE I.—Provisional Glare Factors for 40-Ft-c Installations of Diffusing Globes of 1500 Footlamberts Brightness.

Ceiling 75%, RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Height Above Floor (Feet) 8	9	10	12
10	10	55	30	22	5
	15	100	60	50	20
	20	140	100	75	35
	30	220	140	110	65
	40	260	170	140	85
	60	340	240	200	120
15	10	70	40	27	7
	15	120	80	60	26
	20	170	110	90	45
	30	250	170	130	80
	40	320	240	170	100
	60	400	300	240	150
20	10	80	50	34	10
	20	190	130	100	55
	30	280	200	150	90
	40	360	260	200	120
	60	480	360	280	180
	80	560	440	350	240
30	10	100	55	38	13
	20	240	150	120	65
	30	340	230	180	120
	40	420	300	250	160
	60	580	440	350	240
	80	700	540	440	300
	100	800	600	500	360
40	10	110	60	40	15
	20	250	170	130	75
	30	360	260	200	140
	40	460	340	260	200
	60	640	480	400	300
	80	760	600	480	360
	100	900	680	560	420

Multiplying Factors for Above Table to Correct for Other Wall and Ceiling Reflectances at 40 Ft-c

Ceiling	75			50			30	
Walls	50	30	10	50	30	10	30	10
Multiply by:	1.0	1.2	1.55	1.2	1.5	1.8	1.8	2.3

Multiplying Factors for Other Footcandle Levels

Footcandles	1	2	3	5	10	15	20	30	40	50	60	80	100
Multiply by:	.2	.3	.4	.45	.55	.7	.75	.9	1.0	1.1	1.15	1.3	1.4

able and acceptable for those areas where the seeing task is continuous and critical.[6] Such areas are offices, classrooms, drafting rooms, etc., where the workers are at their tasks over long periods of time and are generally seated in a fixed position with respect to the lighting installation. In contrast, higher glare factors would be permissible and desirable in the lighting of a super-market, because a prime function of such an installation is to attract attention. This is admirably done by a properly designed lighting system.

The Glare Factor System does not attempt to evaluate reflected glare and does not indicate non-uniformity of illumination or shadow conditions. However, it does recognize the importance of work surface brightness. In its present form the method assumes 15 per cent as the average working plane reflectance with desks of 25 per cent to 30 per cent reflectance. The present trend toward high reflection factors for desk tops is gratifying and greater eye comfort is assured. In the case of an increase from a 15 to 35 per cent factor desk top, the glare factor, all other conditions being the same, would be decreased by approximately 15 per cent.

The following glare rating tables have been prepared as representative of seven luminaire types. It is assumed that the observer is seated at the mid-point of one side of the room and has raised his eyes casually from his desk work to a horizontal view about the room. The degree of visual comfort of the observer, as influenced by the direct glare of

TABLE II.—Provisional Glare Factors for 40-Ft-c Installations of Bare Fluorescent Lamps of Average Brightness of 1625 Footlamberts.

Ceiling 75% RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Height Above Floor (Feet) 8 Units End-wise	8 Units Cross-wise	9 Units End-wise	9 Units Cross-wise	10 Units End-wise	10 Units Cross-wise	12 Units End-wise	12 Units Cross-wise
10	10	37	60	30	44	22	26		
	15	45	115	36	90	28	60		
	20	46	170	38	120	30	90		
	30	48	250	41	200	32	140		
	40	50	320	41	250	33	180		
	60	50	440	41	340	35	260		
15	10	50	70	44	50	32	31		
	15	55	130	47	100	35	65		
	20	60	190	50	150	37	100		
	30	60	300	50	240	41	170		
	40	60	400	50	300	43	220		
	60	65	540	55	420	45	300		
20	10	65	80	55	60	40	35	18	15
	20	80	220	65	170	48	110	34	65
	30	80	340	65	260	50	190	38	120
	40	80	440	70	340	55	250	41	160
	60	85	600	70	480	55	360	43	240
	80	85	720	70	580	60	450	43	300
30	10	90	90	70	60	50	36	23	17
	20	115	240	90	190	70	130	50	80
	30	120	380	95	300	75	220	55	140
	40	125	500	100	400	80	300	60	200
	60	130	720	105	580	80	440	65	300
	80	130	880	105	720	85	550	65	400
	100	135	1000	110	840	85	650	65	500
40	10	95	90	75	65	55	36	28	17
	20	135	240	110	190	85	130	60	80
	30	140	380	120	300	95	240	70	140
	40	150	500	120	400	100	300	75	200
	60	150	720	130	600	100	460	80	320
	80	155	900	130	760	105	600	80	420
	100	160	1050	130	900	110	700	80	500

Multiplying Factors for Above Table to Correct for Other Wall and Ceiling Reflectances at 40 Ft-c

Ceiling	75			50			30	
Walls	50	30	10	50	30	10	30	10
Multiply by:	1.0	1.2	1.55	1.2	1.5	1.8	1.8	2.3

Multiplying Factors for Other Footcandle Levels

Footcandles	1	2	3	5	10	15	20	30	40	50	60	80	100
Multiply by:	.2	.3	.4	.45	.55	.70	.75	.90	1.00	1.1	1.15	1.3	1.4

the luminaires and lighted ceiling areas, is indicated by the glare factors.

Tables III, V, VI and VII were prepared by the Electrical Testing Laboratories, Incorporated. These tables attempt to provide representative and practical data for the luminaire types but, due to necessary economies of time and space, do not provide factors for all room sizes and luminaire mountings. In most cases, the given data may be extended, by inspection, to provide estimated factors for rooms and mountings not specifically covered. Note that the computations for these four tables were made for the *initial* condition of a 50-footcandle (maintained) installation and reflectances of 75 per cent for ceiling and 50 per cent for walls. The average working plane reflectance of 15 per cent was mentioned above. The tables include multiplying factors for other footcandle levels.

Tables I, II and IV included for comparison, were previously published.[7] They are for installations of diffusing globes, bare fluorescent lamps and incandescent indirect luminaires. Note that these differ from Tables III, V, VI and VII in that they are for the initial conditions of a 40-footcandle (maintained) installation.

Examples and Comparison

The following glare factors were taken from each of the seven tables, and listed here for comparison. A room 20 feet wide and 40 feet long was assumed to have luminaire mounting height of 10 feet above the floor.

The observer, seated at the mid-point of the 20-ft side of the room, is viewing the length of the room. "Units Endwise" indicates that the luminaires are mounted with their length parallel to the 40-foot sides of the room. "Units Crosswise" indicates that the observer views the same room, from the same position, but that the luminaires have been mounted with their length parallel to the 20-ft sides of the room.

CHART A.—A Comparison of Provisional Glare Factors. Typical Luminaire Types in 50-Footcandle Installations—Room 20′ x 40′.

Ceiling 75% RF; Walls 50% RF; Working Plane 15% RF.

Luminaire Type	Glare Factor Units Endwise	Glare Factor Units Crosswise	Coefficient of Utilization	Luminaire Efficiency
No. 1 — Diffusing Globe Incandescent	220*	220*	.40	80%
No. 2 — Fluorescent Lamps, Bare	61*	275*	.48	100%
No. 3 — Luminous side, 2-Lamp Slimline	65	75	.53	86%
No. 4 — Indirect Incandescent	12*	12*	.35	85%
No. 5 — Decorative, 4-Lamp Fluorescent	11	18	.45	78%
No. 6 — Semi-Direct 2-Lamp	7	8	.48	77%
No. 7 — Low-Brightness 1-Lamp Fluorescent Troffer	21	1.5	.55	68%

*Corrected to 50 Footcandles.

TABLE III.—Provisional Glare Factors for 50-Ft-c Installations of Two-Lamp Semi-Direct Plastic Side Fluorescent Fixtures for 96″ Slimline Lamps. Shielding 20 Degrees Crosswise.

Ceiling 75% RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Mounting Height Above Floor (Feet) 8½ Units Endwise	8½ Units Crosswise	10 Units Endwise	10 Units Crosswise	13 Units Endwise	13 Units Crosswise
15	20	60	50	....	....	....	....
	30	65	75	....	....	....	....
	40	65	90	....	....	42	39
	60	70	120	....	....	50	60
	80	80	150	....	....	50	70
20	30	65	75	60	55	....	....
	40	65	90	65	75	....	....
	60	70	120	70	100	....	....
	80	80	150	70	120	....	....
	100	80	170	75	140	....	....
30	40	70	100	70	80	55	48
	60	85	150	75	110	65	75
	80	90	180	80	130	....	....
	100	90	200	80	160	80	110
40	40	....	....	70	80	....	....
	60	....	....	80	120	....	....
	80	....	....	80	140	....	....
	100	....	....	85	170	....	....

NOTE: Computation made for initial conditions of a 50 ft-c maintained installation and a 75% ceiling reflectance, 50% wall.

Multiplying Factors for Other Footcandle Levels

Footcandles	10	20	30	40	50	60	80	100
Multiply by:	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3

Luminaire types 1 and 2 are included on Chart "A" as well-known, typical luminaires which, although "efficient" are definitely undesirable as regards seeing comfort for critical tasks. In contrast, types 6 and 7 are well designed for delivery of light to the working plane and have very desirable glare factors. Note that luminaire efficiency is not a reliable indicator of luminaire performance either as regards quantity or quality of light. Further, a well-designed luminaire can have both high utilization of light and low glare factors.

The luminaire of type 3, with plastic side panels and modest shielding, illustrates good functional design. This luminaire was developed for store lighting and was intended to provide illumination for vertical surfaces as well as provide attraction

TABLE IV.—Provisional Glare Factors for a 40- Ft-c Indirect Installation of Silvered-Bowl Lamps in Shallow Reflectors. Average Ceiling Brightness About 100 Footlamberts.

Ceiling 75%, RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Ceiling Height (Feet) 9	10	12	14
10	10	3	2	1	1
	15	6	3	2	1
	20	7	5	3	2
	30	8	6	5	2
	40	8	7	6	3
	60	8	7	6	3
15	10	5	3	2	1
	15	8	6	3	2
	20	9	7	5	3
	30	11	8	6	3
	40	12	10	7	4
	60	13	11	7	5
20	10	5	3	2	2
	20	8	7	5	3
	30	11	9	7	5
	40	12	11	7	5
	60	12	11	9	7
	80	13	12	10	7
30	10	6	5	3	2
	20	9	8	6	3
	30	11	10	7	5
	40	12	11	8	6
	60	13	12	10	7
	80	13	13	11	8
	100	14	13	11	8
40	10	6	5	3	2
	20	10	8	6	3
	30	11	10	8	5
	40	12	11	9	6
	60	13	12	10	7
	80	13	13	11	8
	100	14	13	11	8

This table applies for ceiling brightness uniformity of the order of 2.5:1; typical of silvered-bowl lamp installations. If ceiling brightness is distinctly nonuniform, of the order of 5:1, increase the values in the table by multiplying by 1.2. Glare factors for indirect lighting contain no allowance for ceiling beams or ceiling area obscured by luminaires.

Multiplying Factors for Above Table to Correct for Other Wall and Ceiling Reflectances at 40 Ft-c

Ceiling	75			50			30	
Walls	50	30	10	50	30	10	30	10
Multiply by:	1.0	1.3	1.8	1.0	1.3	1.8	1.3	1.8

Multiplying Factors for Other Footcandle Levels

Footcandles	20	30	40	50	60	80	100
Multiply by:	.40	.65	1.00	1.35	1.75	2.70	3.60

lighting, calling attention to the store. This luminaire installed in continuous rows running the length of a 40 ft x 100 ft super-market ceiling (10 ft), and providing illumination of 50 footcandles maintained, results in a glare factor of 85 for the customer entering the store. If the rows were to be mounted across the store the glare factor would be approximately doubled. In contrast, bare fluorescent lamps (luminaire type 2) with much higher "efficiency," would have lower utilization of light and glare factors of 121 and 770, respectively.

Luminaires of type 4, indirect incandescent, have lower coefficients of utilization than the other types here listed, but have high efficiency, simplified maintenance and low glare factors. This re-emphasizes the widely accepted fact that well designed indirect luminaires, properly installed, result in very comfortable illumination.

Luminaire types 5 and 6 illustrate the importance of luminaire brightness and area. The design of type 5 provides 30° shielding of the lamp crosswise and lengthwise. The brightnesses and areas of the luminaire viewed crosswise and lengthwise are not equal and glare factors for crosswise mounting of luminaires are almost double those for lengthwise mounting. Type No. 6, with 40° crosswise and lengthwise shielding of the lamp, has areas and brightnesses which are more nearly equal. The resulting glare factors for crosswise and lengthwise mounting of the luminaires are practically identical. This example emphasizes that comfort evaluations of luminaires cannot be based on mere considerations of mechanical shielding of the lamps or surface brightnesses.

From the chart, tables, and examples, it may be seen that the glare factors offer a simple means for evaluating the comfort of a given or proposed

TABLE V.—Provisional Glare Factors for 50-Ft-c Installations of Four-Lamp General-Diffuse White Louvered Fluorescent Fixtures. Shielding 30 Degrees Crosswise and Longitudinal.

Ceiling 75%, RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Mounting Height Above Floor (Feet) 8½ Units Endwise	8½ Units Crosswise	10 Units Endwise	10 Units Crosswise	13 Units Endwise	13 Units Crosswise
15	20	9	15	....	....	....	....
	30	11	18	....	....	....	....
	40	11	20	....	....	6	11
	60	13	24	....	....	7	14
	80	15	28	....	....	7	14
20	30	11	18	9	15	....	....
	40	12	20	11	18	....	....
	60	15	25	12	20	....	....
	80	17	30	13	24	....	....
	100	17	35	14	26	....	....
30	40	15	22	12	19	9	14
	60	18	30	14	24	11	18
	80	20	35	16	28	....	....
	100	22	40	17	30	13	24
40	40	....	....	13	20	....	....
	60	....	....	16	25	....	....
	80	....	....	18	29	....	....
	100	....	....	20	35	....	....

NOTE: Computation made for initial conditions of a 50 ft-c maintained installation and a 75% ceiling reflectance, 50% wall.

Multiplying Factors for Other Footcandle Levels

Footcandles	10	20	30	40	50	60	80	100
Multiply by:	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3

installation. Application is made by comparison within a chart or between two or more charts. In general, the lower glare factors are more desirable for interior areas where critical seeing tasks are the rule. Higher glare factors are of value chiefly where the lighting installation is at least partly intended as attraction lighting, such as for supermarkets. A luminaire design is aided by a study of glare factors for given lamp types. Such items as reflector contour, materials, finishes, etc., influence the final factors. A study of glare factors for a given luminaire provides useful information for installation of the luminaires, especially where a considerable variation in shielding and/or brightness is apparent when viewing the luminaire from endwise and crosswise position. In some cases, such as a low brightness aluminum troffer, the glare factor for crosswise viewing of the luminaire is a very small per cent of the glare factor of the same luminaire when viewed endwise.

It is felt that the Glare Factors of Harrison and Meaker, based on factual photometric data and requiring no special equipment or further computations for their application, are valuable and practical aids in luminaire design and application.

TABLE VI.—Provisional Glare Factors for 50-Ft-c Installations of Two-Lamp 40-Watt General Diffuse White Louvered Fluorescent Fixtures. Shielding 40 Degrees Crosswise and Longitudinal.

Ceiling 75% RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Mounting Height Above Floor (Foot)					
		8½		10		13	
		Units End-wise	Units Cross-wise	Units End-wise	Units Cross-wise	Units End-wise	Units Cross-wise
15	20	7	8	....	....	....	....
	30	7	8	....	....	....	....
	40	7	8	....	....	5	6
	60	8	9	....	....	5	6
	80	9	10	....	....	5	6
20	30	7	8	7	8	....	....
	40	7	8	7	8	....	....
	60	8	9	8	9	....	....
	80	9	10	8	9	....	....
	100	9	10	8	10	....	....
30	40	8	9	8	9	7	8
	60	9	10	9	9	7	8
	80	10	12	9	10	....	....
	100	10	12	9	10	9	10
40	40	....	....	8	9	....	....
	60	....	....	9	10	....	....
	80	....	....	9	10	....	....
	100	....	....	10	11	....	....

NOTE: Computation made for initial conditions of a 50 ft-c maintained installation and a 75% ceiling reflectance, 50% wall.

Multiplying Factors for Other Footcandle Levels

Footcandles	10	20	30	40	50	60	80	100
Multiply by:	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3

TABLE VII.—Provisional Glare Factors for 50-Ft-c Installations of Single-Lamp 40-Watt (Low-Brightness) Fluorescent Aluminum Troffers. Shielding 40 Degrees Crosswise.

Ceiling 75% RF; Walls 50% RF; Working Plane 15% RF

Room Width	Room Length	Mounting Height Above Floor (Foot)					
		8½		10		13	
		Units End-wise	Units Cross-wise	Units End-wise	Units Cross-wise	Units End-wise	Units Cross-wise
15	20	18	1.5	....	....	....	....
	30	19	1.5	....	....	....	....
	40	20	1.5	....	....	19	1.5
	60	20	1.5	....	....	20	1.5
	80	20	1.5	....	....	20	1.5
20	30	20	1.5	20	1.5	....	....
	40	20	1.5	21	1.5	....	....
	60	20	1.5	21	1.5	....	....
	80	20	1.5	21	1.5	....	....
	100	20	1.5	21	1.5	....	....
30	40	21	1.5	21	1.5	20	1.5
	60	21	1.5	21	1.5	21	1.5
	80	21	1.5	21	1.5	....	....
	100	21	1.5	21	1.5	21	1.5
40	40	....	....	21	1.5	....	....
	60	....	....	21	1.5	....	....
	80	....	....	21	1.5	....	....
	100	....	....	21	1.5	....	....

NOTE: Computation made for initial conditions of a 50 ft-c maintained installation and a 75% ceiling reflectance, 50% wall.

Multiplying Factors for Other Footcandle Levels

Footcandles	10	20	30	40	50	60	80	100
Multiply by:	0.5	0.7	0.8	0.9	1.0	1.1	1.2	1.3

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That the Blind May See

Relighting Program in School for the Legally Blind

By WILLIAM G. DARLEY

THE Texas School for the Blind, founded in 1856, is a residential school. It is provided by the State to assure the education of children having a visual acuity of 20/200 or less. In other words, those permitted to attend the school are legally blind. While the majority of the children accepted may truly be classed as blind, 30 to 40 per cent of them do have partial vision; however, since these partially seeing students cannot read the "small" (sized) print in regular textbooks, in the past they have had to learn to read Braille by touch in order to be able to "read" at all.

When students with partial vision read Braille, they cannot resist the inherent urge to see what they are reading with their eyes rather than with their fingertips. This creates a further handicap to the learning process. While Braille can be read visually, it is a severe eye task, not one to be engaged in for prolonged periods even by those with normal vision. For the handicapped eye, reading Braille can rapidly cause excessive fatigue, thus aggravating the severity of the task. In time, this could force the reader to try to "see" with fingertips not as skilled as they could be. Even in contemplation, it is a frustrating experience.

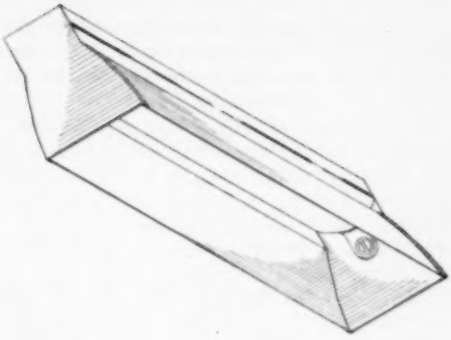
Author: Consulting Engineer, Austin, Texas.

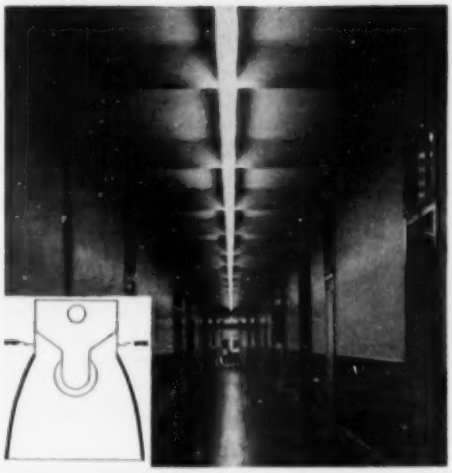
The concept of "sight-saving" has been under study in public schools since the turn of the century. There are today many sight-saving classes in public school systems. As a rule, students are eligible for admission to them if their visual acuity ranges between the 20/200 aforementioned up to 20/70.* Large print textbooks and numerous other large-sized classroom materials are available for use by the students in these classes. The visual environments in their sight-saving classrooms are also usually given special attention. The first really good electric lighting for schoolrooms in many communities has been installed in a sight-saving classroom. Also, the use of light-finished furniture, good painting, and better window shading have often been first tried in these rooms.

The superintendents of residential schools for the blind have been giving the concept of sight-saving special consideration for the past decade. Their first goal was to have suitable large-print textbooks published since the available large-print books used by the long established sight-saving classes in the public schools were not adaptable.

*That is, visual acuities range as follows: In regular classes, from "normal" (20/20) down to 20/70; in sight-saving classes, from 20/70 down to 20/200; in schools for the blind, from 20/200 *down*. An eye with a visual acuity of 20/200 is just able to see at 20 feet what a "normal" eye can see equally well at 200 feet.

Superintendent W. E. Allen of the Texas School for the Blind and his secretary, Miss Mildred Stewart. The desk is illuminated by a U-shaped arrangement (inset) of four 40-watt aluminum-sided, louvered units. Illumination on the desk is 80 footcandles.





In relighting the corridors, a luminaire was designed by the author for this application (shown in line drawings at left and inset, with end plate removed). Illumination levels across the corridor, using this single 40-watt lamp unit range from 20 to 30 footcandles. In addition to acoustical treatment and new paint, a system of Exit Lights has been installed.

The available texts were not correlated with Braille textbooks, nor did they cover all of the subjects it would be necessary to teach; furthermore, they did not make adequate provision for students above the sixth grade. The residential schools carry students through to the completion of their high school work. It would have been rather pointless to start students to reading the available large-print texts, only to have to change them over to Braille in order to complete their education. Also, since all of the students in a class should study together, their texts should be the same whether they are reading Braille or print; and there is always the possibility that a student's acuity will degenerate below the visual threshold for reading the large print, at which time the transition to Braille would be made much easier if the text stood firm and unaltered. A few years ago, the National Printing House for the Blind undertook a program leading to the ultimate provision of large-print textbooks correlated with available Braille texts through the high school level. These texts are available for all grades up to the ninth at this time and will be complete through the high school level by January 1953, according to present plans.

Mr. William E. Allen, Superintendent of the Texas School for the Blind, has been one of the motivating forces behind the changeover in thinking with regard to the education of partially sighted students in the residential schools. As soon as it became apparent that the full line of textbooks would be forthcoming, Mr. Allen started his primary classes on a new system, *i.e.*, those with sufficient vision to read the large print were given printed textbooks, while those lacking this degree of vision were given Braille textbooks.

Now that the "blind" were going to see, Mr. Allen was faced with a brand new problem. Brightnesses and brightness ratios in the visual environment had to be given immediate consideration, for up until now, the classes and classroom buildings had been operated on the basis that all of the students were truly blind. For instance, the lighting in each and every classroom in the Main Classroom Building, irrespective of size, consisted of a single drop-cord with a bare lamp swinging at the end. In the newer primary building, the classroom lighting was far superior — there were two small enclosing globes per room.

In considering how best to teach his charges, Mr. Allen contemplated a challenging alternative to the two conventional teaching practices used in sight-saving classes in the public schools.

In the early sight-saving classes, the student spent all of his time in a classroom set aside and especially treated for the visually handicapped students. He was, therefore, "segregated" from the school society. The second and newer teaching practice is for the sight-saving classroom to be used for study only, the students proceeding to regular classrooms for recitation. Thus, the student is made to feel that he is more a part of the school society and not "different from the rest of the kids." While this second approach is certainly better psychologically, Mr. Allen is not one to be satisfied with even "better" measures. He believes that maximum educational and psychological results can be ob-

Prior to the relighting (above), the library of the Texas School for the Blind was characterized by glare. In the new installation (below) an average of 100 footcandles of comfortable brightness is provided.

tained only by having a normal school society without any segregated groups. In other words, he wanted sightless students and partially seeing students to be seated indiscriminately, with complete disregard for the way in which they would read their books, anywhere in the room in all of their classes. For this reason, Mr. Allen elected to provide a visual environment in every classroom equal to or better than that which one might expect to find in the best isolated sight-saving classrooms in the country.

The first step taken by Mr. Allen was the replacement of existing fixed, dark classroom desks with new movable, light-finished desks. The second step assigned the author the task of designing an "ideal" lighting system, that is, ideal within the practical limits of the available funds. It was also stipulated that acoustical treatment should be applied in all classrooms and corridors.

Once the survey of existing conditions was under way, it did not take long to find out how important the acoustical treatment was to be. At the west end of the building, on both the first and second floors, are one large room and sixteen small individual practice rooms set aside for the study of music. The walls and ceilings of these rooms, of the corridors and of all classrooms were bare plaster. While the mastery of a musical instrument is wonderful for the morale of the blind students, the cacophony reverberating down the corridors and echoing into the classrooms produced an auditory environment which was as bad or worse than the existing visual environment.

In the author's opinion, the most logical solution to the problem presented would have been continuous rows of single-lamp, louvered, deep aluminum troffers for 40-watt T12 fluorescent lamps installed on two-foot centers and recessed in an acoustical ceiling.* Preliminary cost estimates indicated, however, that the cost of this system would exceed the available funds. As a result, the plans and specifications were drawn around the use of two (40-watt F) lamp, aluminum sided, louvered fixtures installed in continuous rows on four-foot centers, with acoustical tile to be applied independently of the lighting equipment. An alternate bid was taken for the aluminum troffer system, but, as anticipated, the cost was "out of the money."

Late in 1950, a contract was let for the lighting of the entire Main Classroom Building and two classrooms in the Primary Building.** Included in the cost was an entirely new electrical distribution system insofar as secondary service entrance, main switchboard, feeders and panelboards were concerned. Wherever possible, use was made of existing branch circuit and switch-leg conduits. Some idea of the extent of the change can be gathered from the fact that the lighting load for the Main Building, "as found," was served by one seven and one-half kva transformer. It is now served by three seventy-five kva transformers.

Lights are controlled by two or three switches in each regular classroom, depending on the size of

*It was possible to illustrate this quality of lighting locally, inasmuch as such installations had been made in the drafting rooms in the State Highway Building in Austin.

**The area (within the confines of the exterior building walls) which was relighted, covers approximately 54,000 square feet. It includes 21 regular sized (21' x 30') classrooms, 32 small music rooms, three long (over 200') corridors, two gymnasiums, a large library, and numerous other rooms.

the room. The teachers, therefore, can use part, all, or none of the lighting, as they see fit. The illumination level in the classrooms, from the electric lighting, is presently ranging around 150 footcandles with all fixtures operating. The system, however, has been installed completely only about six months with the lamps having been in service relatively little of the time, due to the summer vacation period.

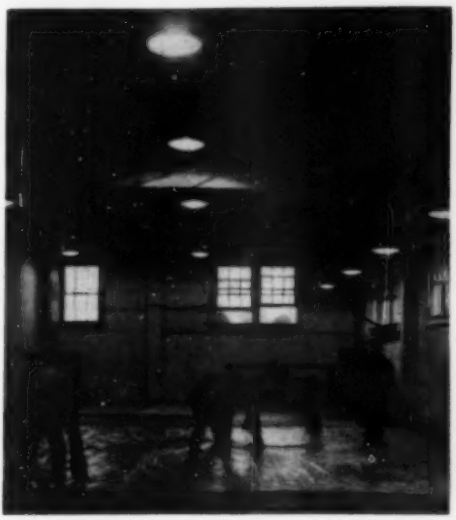
It was also the privilege of the author to do the engineering for the final phase of the work to be done by outside contract. In the Main Classroom Building, all relighted spaces* on the first and second floors and the stairwells to the basement had wall surfaces patched and painted. Premixed wall paint colors were used pure or mixed with white paint to achieve the colors and reflection factors desired for walls. Premixed enamel colors were used in the same manner for trim and woodwork. Cement floors and steps were painted a medium grey. Wall and trim paints were used pure (unmixed with white) and mixed. Mixtures used were 1:1 (white to color), 2:1, 4:1 and 8:1 (white to color). This resulted in a change in the reflection factor of the Stratosphere Blue color, for instance, of from 30 per cent when unmixed to 58 per cent when mixed 8:1.

In spaces with acoustical treatment applied to the ceiling, the wall color was brought up to the tile; where there were beams in such spaces, they were painted the same as the walls. Ceilings of rooms without acoustical tile were painted white. Colors chosen for the various spaces were selected on the basis of room usage, size, orientation, outlook, etc. For instance, the library** on the first floor at the east end of the building has the ceiling white, the walls Sun-tone (a yellow), mixed 2:1, and the trim Sun-tone enamel, mixed 1:1. For stairwells, the ceilings are white (where acoustical tile is not applied), walls are Sun-tone, mixed 1:1, trim and dado are Eye-Rest Green, mixed 2:1 and floors are the medium grey. Rest-rooms have Rose Tan walls and trim. In general, regular classrooms have Cascade Blue and Sea Foam Green walls and trim, while the very small music rooms have Stratosphere Blue walls mixed 8:1 and Stratosphere Blue trim mixed 4:1.

The final step, which Mr. Allen hopes to take soon, is to be the refinishing of wooden floors in classroom areas, in order that their reflection factor may be raised to complete the improvement in the visual environment.

For those of us acquainted with the audio-visual conditions prior to the renovation, it does seem that a minor miracle has taken place in the transformation of an ill-lighted, noisy, drab environment devoted to the teaching of the "blind" to a cheerful, bright, quiet environment which was created in order that the "blind" may see.

The author is indebted to Superintendent William E. Allen for his assistance in the preparation of this manuscript.



Four units of the type shown above supplied illumination in the 29 x 72 foot gymnasium prior to the renovation. The lighting (below) is provided by 18 300-watt lamps in standard domes with wire guards. Between 30 and 40 footcandles are supplied. The wrestling team of the Texas School for the Blind is shown practicing.

*The auditorium and stage were not involved in the renovation.
**Not acoustically treated since it is largely devoted to stacks.

Lighting a Hotel Mail Board

LIGHTING OBJECTIVE: To provide an automatic light signal device to show hotel guests whether they have any mail.

Figure 1. Mail Board.

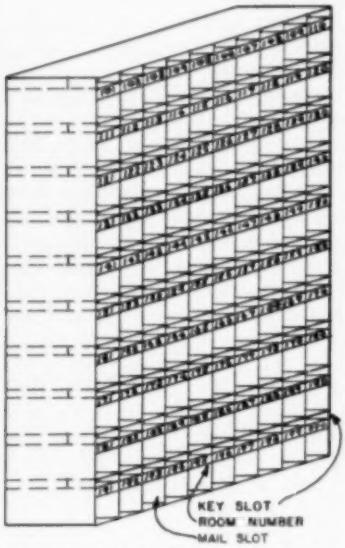


Figure 2. Rack of 100 mail and key slots.

Installation at La Salle Hotel, Chicago, Illinois.

General Information: This system was conceived to inform hotel guests at a glance whether or not they have any mail, thereby minimizing inquiries at the mail desk. It also has reduced room burglaries considerably since the mail and keyboxes are located behind the mail and information counter and are not visible to anyone in the lobby. There are ten rack units each providing openings for 100 rooms.

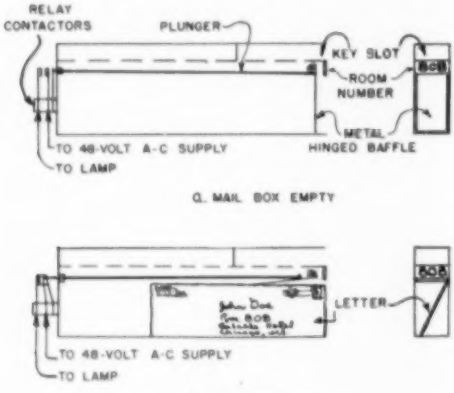


Figure 3. Detail of baffle and plunger system.

Lighting Installation: A hinged baffle at the entrance to the mail compartment pushes a plunger against spring contacts to activate the 48-volt indicator lamp when a letter is inserted in the box. When the letter is withdrawn the hinged baffle swings down, the pressure is taken away from the plunger and the contacts spring apart. Each unit is readily removable for servicing. A master switch is available in the circuit to light all 1000 lamps to check the panel-board for lamp failure.

Installation was designed by Roy Steffin, the hotel president, and constructed by Rapp and Rapp, Architects and Consulting Engineers, 230 N. Michigan Ave., Chicago, Illinois.

Lighting data submitted by J. H. Herbenar, General Electric Company, 231 South La Salle Street, Chicago as an illustration of the application of signal lighting.

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Seeing Against Headlamp Glare

By VAL ROPER
G. E. MEESE

THERE is not complete agreement, even among the "experts," as to the best answer to the motor vehicle headlighting problem. That there is a problem is attested by the amount of tinkering with factory-installed headlamps with the object of alleviating glare. Glare is the attribute of motor vehicle lamps of which people are most conscious. In their attempts to overcome the annoyance of glare many designers overlook the fundamental requirement that headlamps should provide seeing distances somewhat in excess of stopping distances for normal driving conditions. Unfortunately even the modern sealed beam headlamps do not provide seeing distances in excess of stopping distances for many regularly encountered driving conditions. The reasons (forgetting for the moment physiological factors such as poor eyesight and fatigue) are insufficient intensities of light directed far enough ahead, and veiling glare from approaching vehicles.

Data from previously reported researches using observer-drivers have shown the relation between beam candlepower and seeing distances for clear road driving,[1] the effect of glare upon clear road seeing distance for the critical condition of a stationary opposing car,[1] seeing distances when approaching another moving vehicle on a two-lane road,[2,3] and an appraisal of glare in terms of annoyance.[4] The chief objective of the research reported here was to determine whether any practical combination of upper and lower beam patterns properly used could be evolved which would close up the present gaps between stopping and seeing distance values.

With sealed beam headlighting, most drivers "signal" for relief at distances well in excess of the optimum distance for depressing the beams. This optimum distance, that is the point at which the seeing distance with an upper beam facing an upper beam and that with a lower beam facing a lower beam becomes the same, is 800-1200 feet between the two cars,[2,3] on a straight, level two-lane road. On this straight, level road, many drivers "ask" for depressing at distances up to 3000 ft, and usually at 1500 ft or more. Yet if the beams are depressed when the cars are much more than 1000 ft apart the seeing distance often drops below stopping distance at legal speeds. And it again often drops below stopping distance for the last 100 to 200 feet before meeting.[3] The reason for this drop in seeing distance is, of course, the veiling glare from the opposing headlamps combined with insufficient light to counteract the glare. The recently developed Taylor-Pracejus illumination recorder[5] has made it feasible to add considerably to our quantitative knowledge of the effect of the glare factor. Combined with techniques employed previously for seeing distance measurements with observer-drivers[2,3] it provides a simultaneous record of footcandle intensity at the drivers' eyes.

The Taylor-Pracejus illumination recorder is a paper tape recorder driven by a power take-off from the speedometer cable. The model used in these headlighting tests has three marking pens. One draws a continuous graph of footcandles picked up by a photocell mounted on the windshield. Another draws a distance base line at one edge of the tape and makes a "pip" in the line when the horn ring is touched. The third pen draws a distance base-line on the opposite edge of the tape and makes a "pip" in the line when a button is pressed on a data board held in the lap of the data recorder riding in the front seat with the observer-driver.

In the present study, the following test procedure was used: Two cars, each equipped with the test headlamps, a Taylor-Pracejus illumination recorder, an observer-driver and a data-recording engineer, were started at opposite ends of a 1.2-mile stretch of straight, level roadway with a clean concrete surface. The tests were run on moonless clear nights. Ten identical test obstacles were placed along each edge of the travelled road. They consisted of squares of treated paper board having a reflectance of 8.5 per cent. The squares were 16 inches by 16 inches and were selected as similar to those used in the international headlamp comparisons conducted by the ICI committee at Zandvoort, Holland, in October of 1949. They simulate the hazard presented by a small animal and are seen about as easily as a pedestrian. These test obstacles were distributed ahead and behind the meeting point: 1500 feet ahead, 1000, 600, 300, 100 ahead,

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Engineering Department, Lamp Division, General Electric Company, Nela Park, Cleveland, Ohio.

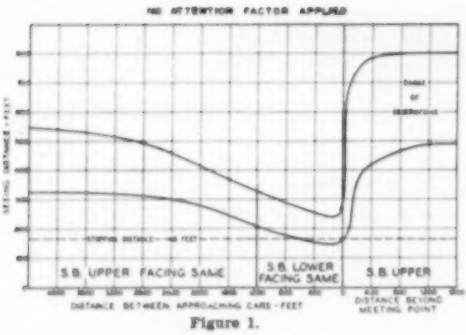
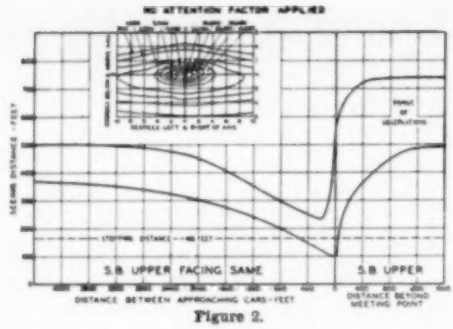

NO ATTENTION FACTOR APPLIED
S.B. UPPER FACING SAME
S.B. LOWER FACING SAME
S.B. UPPER
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 1.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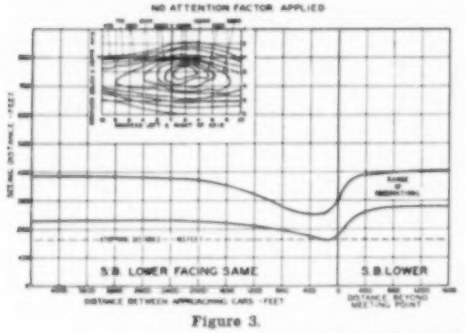
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 2.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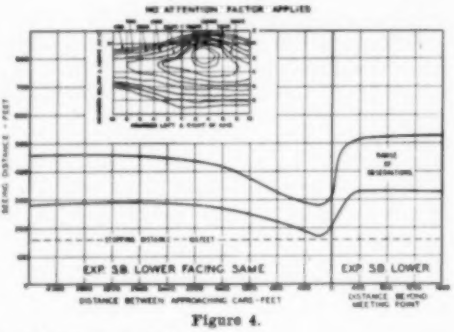
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 3.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EXP. SB. LOWER FACING SAME
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DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 4.

Seeing distances while driving on two-lane road.
Road Width: 21 ft. Car Speed: 40 MPH
Obstacle: 16" Square with 8.5% Reflectance

100 behind, 300, 600, 1000, and 1500 feet behind. The two cars started at a signal, accelerated to 40 mph and held that speed for the test run.

Upon perceiving each obstacle, the observer-driver depressed the horn ring, thus marking the tape on the illumination recorder. As the obstacle was reached, and passed, the individual riding to the right of the driver pressed the button which "pips" the opposite side of the paper tape. The linear distance between the pip made by the driver and that made by the recorder is the seeing distance—the distance at which an attentive driver, knowingly engaged in a test can perceive a 16" square obstacle from a car proceeding at a speed of 40 mph. With the succession of 10 obstacles distributed ahead and behind the meeting point a seeing distance curve can be determined, for the driver approaching and proceeding beyond another car. Six observers were used, all with "20/20 acuity" and with average or better than average, night vision according to the Luckiesh-Moss low-contrast sensitivity chart.[6] Enough test runs were made to obtain at least four observations for each obstacle position for each of the six observer-drivers.

Figs. 1 to 4 show the seeing-distance curves for four different headlighting conditions tested. The vertical dimension of the band represents the total spread in the readings with the six observers. A stopping-distance base line of 165 ft (from 40 mph) is included to facilitate comparison of seeing-distance and stopping-distance values.

In considering these comparisons, one should keep in mind that these tests were conducted under conditions more favorable than obtained in normal driving and that therefore the seeing-distance values shown are relatively higher than could be expected in normal practice. Previous test data[1] disclosed an attention factor of 0.5. That is, an observer-driver looking for test obstacles he knows may be there, sees them twice as far away as he would if he were not knowingly participating in a test. This attention factor was determined for clear road driving. We know of no test evaluation of this attention factor for the condition of meeting another vehicle, but since one normally pays closer attention to the lane of travel immediately ahead when another car is approaching, it is reasonable to assume that the factor is between 0.5 and 1.0—probably of the order of 0.7.

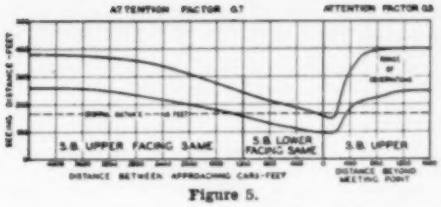


Figure 5.

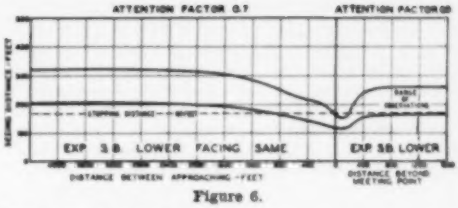


Figure 6.

Seeing distances while driving on two-lane road.
Road Width: 21 ft. Car Speed: 40 MPH
Obstacle: 16" Square with 8.5% Reflectance

Figs. 5 and 6 show the seeing-distance curves with standard sealed beam headlamps and with such headlamps modified to incorporate an experimental lower beam. The attention factors applied are 0.7 for the meeting portion, and 0.5 for the clear road portion. These data show that an alteration of the sealed beam lower beam which provides higher intensities nearer the top right side of the beam pattern gives increased seeing distances. And these were obtained in spite of a moderate increase in glare values (see isocandle curves, Figs. 3 and 4). Even so, the lower portion of the curve still dips below the stopping-distance line for a short period.

If one considers further the normally encountered changes in direction and elevation of the roadway, and a reasonable variation in headlamp aiming, it becomes obvious from an analysis of these data that our present headlighting system cannot provide seeing-distance values which are always in excess of stopping distances for normal driving *on a two-lane road.*

Fig. 7 shows the relation between footcandles at the eye and per cent clear-road seeing distances — for the condition of a two-lane road of 21-foot width. These data can be of assistance in calculating the separation between lanes required to permit the use of either an upper beam, or the improved lower beam and yet limit the glare-producing footcandles at the eye to a value which will not reduce seeing distances to stopping-distance values. Figs. 8 and 9 show seeing-distance values as measured on a divided highway with 21-foot separation between lanes. The seeing distance with upper beams is considerably improved over that on the two-lane highway. But the glare annoyance (with only 21-foot separation) is such as to preclude the use of upper beams when approaching other vehicles within 1000 feet.

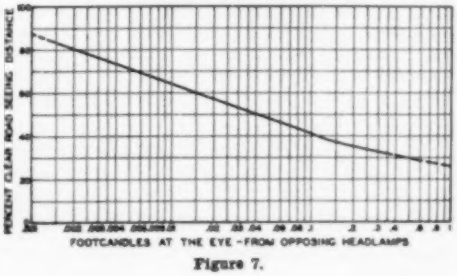

EFFECT OF HEADLAMP GLARE ON SEEING DISTANCE
TWO-LANE ROAD WIDTH 21 FEET
PERCENT CLEAR ROAD SEEING DISTANCE
FOOTCANDLES AT THE EYE - FROM OPPOSING HEADLAMPS

Figure 7.

Unfortunately, divided highways with sufficient separation between lanes will not supplant all of our rural road mileage in the foreseeable future. There still remains another method by which headlamps can furnish more light for seeing and with greatly reduced footcandles at the eye, and thus provide seeing distances in excess of stopping distances. Polarized headlighting has been considered by a joint activity of automotive engineers and state motor vehicle administrators.[5] The chief deterrents to its adoption are the time of transition — the time for replacement of the vehicles now on the road — and the problems of mixed driving incident to the transition period. The benefits of polarized headlighting — safe seeing distance and the comforts of glare relief are fully realized only after all cars on the road are equipped. But during the transition period, seeing distances should average slightly higher than at present — with the promise of continued improvement.[3, 5]

The authors plan, in a further study, to use the Taylor-Pracejus illumination recorder to gather additional data on the annoyance aspect of glare which would supplement those presented by Finch.[4] The recorder can be used to correlate subjective evaluations of annoyance from glare with footcandles on the eye. It so facilitates the observations that one can cover a representative cross-section of drivers including the factors of age, normal and sub-normal vision, fatigue, etc.

Taking Finch's data[4] and those presented here it would appear that when a driver meets glare which he considers "objectionable" he should proceed with caution because the chances are his seeing-distance for critical obstacles is reduced below stopping-

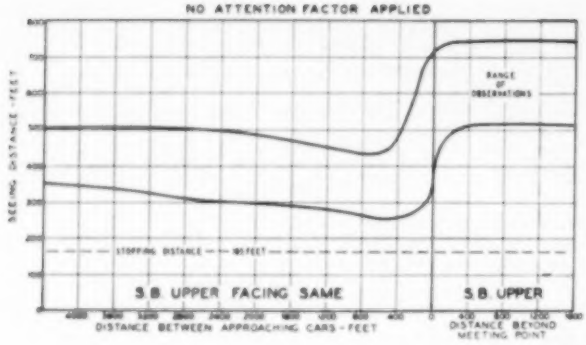
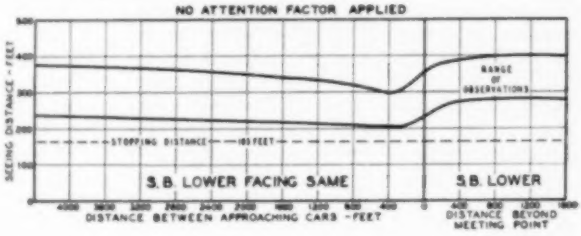

NO ATTENTION FACTOR APPLIED
SEEING DISTANCE - FEET
RANGE OF OBSERVATIONS
STOPPING DISTANCE — 485 FEET
S.B. UPPER FACING SAME
S.B. UPPER
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Figure 8. (Left)
Figure 9. (Below)


NO ATTENTION FACTOR APPLIED
SEEING DISTANCE - FEET
RANGE OF OBSERVATIONS
STOPPING DISTANCE — 485 FEET
S.B. LOWER FACING SAME
S.B. LOWER
DISTANCE BETWEEN APPROACHING CARS - FEET
DISTANCE BEYOND MEETING POINT

Seeing distances while driving on divided highway
Lane Separation: 21 ft. Car Speed: 40 MPH

distance values. However, the situation does not appear quite as hopeless as indicated by Bone[9] who develops 20 beam candlepower as a practical limit from opposing headlamps 100 feet away. This is 0.002 footcandles at the eye, one-ninth the value Finch found objectionable and which according to Fig. 7 reduces clear road seeing distance about 20 per cent or to a value which is still well above stopping distances at legal speeds.

All of the seeing distance data reported here and in the references cited are for single meetings under favorable conditions. The night seeing situation averages worse than indicated by these data which to a large degree explains the greater hazards now attending night-time travel. We can and should improve the situation with a modification of the sealed beam lower beam to provide the increased seeing illustrated by Figs. 4 and 6.

We wish to acknowledge our indebtedness to General Motors for the use of their Proving Ground facilities and assistance in running the tests, to Libbey-Owens-Ford for observer-drivers and to K. R. Dean, Glenn Pracejus and Frank Bowers of General Electric for their assistance in the tests and calculations.

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DISCUSSION

EVAN P. BONE*: Messrs. Roper and Meese deserve to be complimented for their courage in dealing directly with headlamp glare. So often this troublesome problem seems to be evaded. Mr. Roper and colleagues are to be further thanked for the many comprehensive test programs which they have carried out in the cause of better headlighting.

The opening sentence of the present paper mentions the lack of complete agreement as to the best answer in headlighting. Near the end of the paper, the authors mention the need, upon occasions, for a driver to proceed with caution when facing glare and that the night seeing situation averages worse than indicated by the data. But the paper further says that the situation does not appear quite as hopeless as indicated by some data which I reported in National Research Councils Highway Research Board Bulletin No. 34 of this year.

Some explanation seems to be due. In spite of first appearances, the data from the different sources may not be so divergent after all. Any lack of concurrence seems to be a matter of immediate objectives. Mr. Roper has consistently dealt with practical problems of devices as current-

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ly available. No objection can be made to the direct and concise approaches which he so aptly employs.

On the other hand, the approach which I followed was an effort to deal with the ideal conditions in which the illumination on the road and the glare in the eyes are such as to permit the eye to function at near maximum efficiency. In other lines of engineering the ideals such as 100 per cent efficiency are used. Then by measuring the per cent efficiency of an actual device we learn how much room there is for improvement. If the ideal, or 100 per cent, in headlighting can be held before us there may be more inspiration for major improvement.

That the test results from the several sources are actually in basic agreement and that it is mostly a question of what we need to see may be indicated by a couple of examples.

1. In the test studies which I reported, it was assumed that the driver should be able to see straight ahead of his course of travel and as far ahead as he naturally looks when driving in clear road or in daytime. In investigations described in the present paper the test targets are off to the side of the road and the criterion for seeing is only 165 feet ahead. In looking straight ahead, the angle between the line of sight and the source of oncoming glare is small. Therefore, any glare is more detrimental to visibility and needs to be reduced for comparative seeing.

2. Now for the other item. When looking at far ranges, straight ahead of the course of travel, the adaptation brightness of the driver's eyes is only about 1/10th as high as when looking down at the edge of the road near the foreground area of maximum illumination. The reason for this is that when looking straight ahead, near the horizon, the relatively bright foreground acts merely as an "off the axis" source of glare located in surrounding region of the field of view. It is not imaged on the fovea of the retina. The effect is that when the adaptation brightness is reduced to 1/10th, the opposing headlamp glare must correspondingly be reduced to about 1/10th for maintenance of equivalent visibility.

So the apparent differences in reported data depend mostly upon the degree of visibility which is assumed or even the degree of safety which we are trying to accomplish; whether we are to have no more driving hazards than in daytime, 10 per cent more, 100 per cent more or what? Contrast sensitivity is a pretty good measure of visibility. When I reported (Reference 9 of paper) that some tests indicated that to get contrast sensitivity when cars meet up to 80 per cent of the contrast sensitivity when alone in clear road (with the same beam), the opposing glare must be reduced to about 20 cp, it was received with skepticism. But it is hoped that serious consideration may be given to this line of study.

D. M. Finch*: The authors note that there is not a complete agreement, even among the "experts" on the best type of headlight beam distribution for best roadway seeing. Even though there is no agreement among the experts on the exact design, the principles for good headlighting design are fairly well defined.

These design features are well worth restating at this time to clarify the situation as to what a designer should consider as an optimum beam pattern. We might say that a headlight beam should be designed for three basic purposes: (1) the beam should be designed for good seeing from the viewpoint of the driver behind the headlights; (2) the beam should be designed for reduced glare in the eyes of the opposing driver; and (3) the beam should be designed for the best performance under adverse weather conditions. These three basic considerations, especially items (1) and (2), seem to be almost diametrically opposed to each other, for if one places enough light on the roadway to provide the driver with adequate visibility distances, it is almost axiomatic that he will have to have too much light in the upper left-hand portion of the beam for comfortable seeing by an opposing driver.

The design conditions, however, can be broken down and the conditions stated somewhat more in detail in order to give a designer some tangible set of specifications upon which to work. In designing a beam for good seeing, the primary consideration should be one of obtaining as uniform as possible a pattern of pavement brightness ahead of the vehicle. This of course cannot be completely achieved because the light flux available from the headlight is limited. Therefore, the field on the roadway that can be covered will be necessarily limited to some reasonable distance ahead of the car and will have to have tapering brightnesses at the edges in order to relieve the top, bottom, and sides of the beam from very sharp contrast.

The maximum visibility distance should be designed for, which means that the beam will have high intensities near the top edge of the beam. Such a beam design becomes quite critical for aim and adjustment. Therefore, particular attention will have to be paid to this property. This design infers, of course, that there will be one type of aim for open-road viewing where long visibility distances can be achieved, and another type of beam attained either through separate lamps or some form of beam control in the open-road country driving lamps to give a different beam pattern when approaching other cars.

Thus, a beam design which includes the features for reduced glare for the opposing driver will have low intensities in the upper left-hand quadrant. This will mean some form of asymmetric beam for the passing condition and will mean that the passing beam will be the most critical beam of the two. With the open-road driving beam, there can be considerable spill-light both to the sides and above the horizontal, whereas, with the beam designed for reduced glare, that is, the passing beam, it is necessary to have very critical directional control of the light.

Since the light control in the passing beam is very critical the design should incorporate such features as will permit the best optical design. These features would include an on-focus passing lamp filament, which would permit the maximum control of the passing lamp beam. At present, this is not the case. The upper beam filament is placed on-focus and the lower beam is a compromise design. The aiming of the asymmetric lower beam would become quite critical; therefore, it is suggested that a better aiming scheme be incorporated into the optics of the system than is currently the practice. It is also suggested that from an installation and maintenance standpoint, the lower beam should be used for aiming and adjustment.

In designing for the best adverse weather headlamp, it is suggested that the practices that are used for fog lamps and lamps especially designed for adverse weather should be incorporated in the headlamp design. These features include a filament cap over the upper front quadrant of the filament to prohibit the direct rays from the filament emanating through the lens into the upper zone from horizontal to vertical. This light that emerges directly from the filament is very detrimental in seeing under adverse weather condi-

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tions since it is reflected directly into the eyes of the driver from the fog and dust particles than are present in the air. Also, it is suggested that the prism facets on the lens, itself, should be either treated or designed in such a manner that the light reflections from these surfaces do not emerge at high angles to the horizontal. In other words, at present there are striations of light of rather high intensity that emerge from the prism facets on the lens that could and should be eliminated.

One design feature that can be incorporated to provide relief from this is the method of aiming the reflector in such a way that the axis is not horizontal but is tilted down. Then the prisms in the lens may be reversed from the normal design positions to bend the beam from the reflector up onto the roadway rather than down onto the roadway. This design will help to eliminate these reflections from the prism facets.

Referring specifically to the paper and the presentation of the data, it is suggested that the curves should indicate the actual distribution of the data; that is, should show the points for the individual observers, rather than the range of data. This will give a better indication of just how the observers were grouped and will tend to eliminate placing too much weight on single observations that are at considerable variance from the average. It is also suggested that from a statistical point of view it would be desirable to have more observations per observer. If necessary, it would be better to limit the number of observers and obtain more data from each observer.

Reference is made in the paper to the use of polarized headlighting to the effect that it is a technical solution to the glare problem. At the present time, polarized headlighting is on the shelf. It should not remain so, but should continue to receive additional study on the merits of the system. Even though there may be technical, legal, and economic reasons why the system cannot be used or installed at the present time, it still appears to offer enough merit to warrant further study. The next step in the program would seem to be a large scale trial installation under controlled conditions over a period of several years. The data that would be accumulated under such a program could then be studied and evaluated to determine whether or not a larger scale installation of equipment would be justified on all motor vehicles in the country. The magnitude of such a trial seems to discourage the initiation of the investigation, but there are other experiments of equal magnitude that are proceeding where the potential benefits are not spread out over so large a section of the population as the potential benefits of polarized headlights might be. The exact method of procedure in organizing such a large scale test is not clear, but is one that we should all be thinking about to attempt to get some method of support for the activity.

The latter part of the paper deals with the measurement of the illumination at the eye for various observer-driver conditions, that is, at conditions where the observer-driver feels the glare to be objectionable and intolerable. Such measurements need to be made on a fairly large scale in order to definitely tie down the conditions under which the degrees of glare occur. Such data are necessary before a designer can adequately define the type of beam distribution that should be built into a headlighting device. The preliminary measurements made by the authors show that the illumination at the eye for glare is very small. These data seem to substantiate previous data obtained by this writer under actual roadway conditions several years ago. It is recognized, however, that the initial data were quite meager and that the present data in this paper are also quite limited. Therefore, before any definite conclusions are drawn as to the limits on the illumination at the eye from opposing cars for various degrees of glare, it is suggested that considerably more field data be taken. This, I have been assured, the authors plan to do.

V. J. Roper and G. E. Meese*: As Mr. Bone indicates, the results of his "laboratory" analysis and those of our field studies are not necessarily divergent. We prefer seeing distance measurements using observer drivers because we threby weigh in factors which cannot be included in stationary measurements. In the final analysis, for this field, data on contrast sensitivity, dark adaptation, and glare footcandles at the eye are of value in terms of their bearing on seeing distances. We believe that we short circuit a considerable amount of controversy when we measure seeing distances with reasonably typical obstacles under driving conditions.

Our "criterion for seeing" was not "only 165 ft. ahead" as indicated by Bone. The distance of 165 feet was referred to as a typical value of stopping distance from 40 mph. Our observer drivers were looking ahead as they normally would in approaching, meeting and proceeding beyond an opposing vehicle. The test targets were on the road at the edge and within the normal line of vision. Our drivers' degree of dark adaptation was what would normally be encountered on a concrete road under the condition of meeting another vehicle. Obviously the degree of dark adaptation changes with traffic volume, with different road reflectances, and with upper and lower beams. These variables are resolved in the driving test procedure.

The experimental lamps producing the beam that was used to obtain the data of Fig. 4 incorporate some of the features discussed by Finch: Higher intensities directed near the top of the right-hand side, "fog cap" intercepting direct filament light, and lens and reflector design to minimize reflections at critical angles from lens facets. And the traffic beam used in the tests described in Bulletin No. 11 of the Highway Research Board (Reference 8) was produced by lamps using "in focus" filaments. These also had "fog caps" and treatment to reduce facet brightnesses. But few drivers liked the beam pattern because of its relatively sharp upper edge (inherent in the design suggested by Finch) and there was a decided tendency to want to aim it so high as to cause serious annoyance to opposing drivers. One of the first experimental two-filaments sealed beam headlamps had the lower beam filament at the focal point.

As an illustration of our first statement in the paper, Professor Finch is one of the well-qualified "experts" in this field with whom other experts sometimes disagree. There is far from complete agreement on the merits of the "in focus" passing beam filament, or of polarized headlighting. But even the experts agree with the driving public and each other that there *is* need for improvement.

Prof. Finch's comments point to the need for accurate aiming of any headlamp device and especially if improved along the lines he suggests. Excepting in those states and cities requiring periodic inspection of vehicles all too few service stations or garages have adequate facilities for headlamp aiming. And drivers have not been educated to demand such service. Misaim of only ½ degree spells the difference between good and poor performance of any headlamp device. Hence a satisfactory solution of this headlighting problem definitely demands education of drivers to the need of exact aim plus service facilities to provide it.

*Authors.

Cotton Classing by Artificial Light

By DOROTHY NICKERSON

TODAY, cotton men are finding that, in addition to filtered tungsten, a combination of fluorescent and tungsten lamps can be sufficiently well standardized to provide an amount, diffusion, and color quality of illumination that will satisfy all but the most stringent of their requirements. And this fluorescent combination is so very much lower in cost than the filtered tungsten that it can be installed economically, in accordance with standard procedures, to light entire classing rooms fully and evenly. Classing may be done in any part of such rooms; it need no longer be confined to the restricted areas provided by earlier lighting installations, natural or artificial.

Because of the really phenomenal growth in the past two years in interest and application of lighting in this specialized field, a report on the details — for cotton men and illuminating engineers — may be useful.

For many years the United States Department of Agriculture has provided leadership in setting specifications for lighting of cotton-classing rooms. What is known as a Government-type skylight[1,2] was developed as long ago as 1914, in connection with services rendered under the Cotton Futures Act, and since then under the Cotton Standards Act. Artificial lighting was tried out as long ago as 1919 in the New York offices of U.S.D.A.'s Cotton Branch by use of carefully designed daylight luminaires. Although this early experiment, done on a very limited scale, proved that cotton could be classed satisfactorily under artificial daylight lamps, and although the quality of the light provided a good daylight substitute, classing under the lamps was awkward and no immediate progress was made toward their use.

In 1931, in connection with studies of natural daylighting conditions in classing rooms equipped with north skylights, a study of the amount and distribution of light in such rooms was initiated. Preliminary measurements were made in our Washington classing rooms. In 1935-36 the work was extended to include all of U.S.D.A.'s larger classing rooms. A summary of results is given in Tables I and II. In 1937 we became actively interested in exploring the possibilities of developing specifications that would provide satisfactory auxiliary lighting units for use in the classification or grading of a number of agricultural products in which color is an important factor. The information developed in the 1937-40 studies was reported to the Illuminating Engineering Society and to the Optical Society of America in a series of three papers.[1,2,3] On completion of this work, specifications for artificial daylighting were established to include: diffuse reflection over a relatively wide area from a wide angle source; color and energy distribution close to that of a moderately overcast sky at 7500K; 60 to 80 footcandles* on the classing tables. Since the early reports there has been another[4] that has upheld the choice of 7500K as the minimum color temperature preferred in the general field of textile color matching when the amount of illumination was not over 100 footcandles.

Both filtered tungsten, consisting of special glass filters used over high wattage tungsten filament lamps, and a special unit of fluorescent lamps** combining daylight and blue to give the required color temperature, were used in the 1938-40 tests. At that time, when use of any sort of artificial lighting was viewed skeptically, the preference was given to filtered tungsten on the basis of both technical requirements for a daylight substitute and practical classing tests. These tests were made in three classing rooms, those of the United States Department of Agriculture in Washington and Memphis, and the Houston classing room of Anderson, Clayton & Co. As a result of these tests, about ten years ago units of filtered daylight made in the form of cotton classing skylights were installed in nearly every classing office of the Cotton Branch.

Use of these lighting units by classing offices of the Cotton Branch has been spasmodic. While the majority of classers seemed to feel that they could satisfactorily class cotton under artificial light, the small area illuminated by single units and their

Author: United States Department of Agriculture, Production and Marketing Administration, Cotton Branch, Washington, D. C.

*This is well above the minimum of what was called Very Good for December conditions of natural daylighting. It was set above the minimum so that even with a considerable reduction in lumen output, there will be enough light for classing. For color work with dark colors this specification would have to be increased.

**The engineering laboratory of one of the lamp companies cooperated in 1939 in providing daylight and blue flourescent lamps for experimental use before they were generally available to the public. A well-engineered fixture for varying the amount of blue to provide an increase in color temperature from the 6300K of the daylight tubes to a combination that calculated 13,000K was also provided.

TABLE I.—Average of Maximum and Minimum Illumination in Footcandles Read Hourly over 30-day Periods in June and December, Using a Weston Photocell Meter for Certain Sky and Classing Conditions (For Horizontal Plane).

Classing conditions	Sky conditions: Clear		Slightly cloudy		Overcast	
	June	December	June	December	June	December
Very good	108-150	41-50	126-155	52-65	109-150	115-150
Good	118-145	51-60	147-174	64-77	204-252	116-122
Fair	109-149	37-48	138-158	65-75	137-160	80-91
Poor	119-148	31-36	140-168	65-74	99-118	61-70

TABLE II.—Average of Maximum and Minimum Illumination in Footcandles for Classing Designated as "Good" in Table I.

Classing room (location)	Weather conditions: Clear		Slightly cloudy		Overcast	
	June	December	June	December	June	December
Washington (new bldg.)	180-190	34-45	220-235	45-55	220-250	.....
Washington (old bldg.)	120-140	40-50	200-230	65-75	250-275	55-65
Austin	120-150	80-90	130-160	150-160	270-310	175-190
Memphis[1]	85-100	55-60	110-120	50-60	.....	.....
Memphis[2]	140-240	80-105	220-295	70-100	200-250	.....
Houston	130-140	50-60	140-150	75-85	150-160	.....
Charleston	130-150	45-55	110-115	50-60	250-350	140-150
Atlanta	60-70	75	130-140	60-75	.....	90
Savannah	130-150	.....	140-150	60-70	.....	.....
New Orleans	70-90	12-13	80-110	14-19	90-125	.....
Dallas	180-220	30-40	150-185	55-70	.....	.....
Stoneville	70-100	54-60	140-200	75-90	200-300	120-125
AVERAGE	118-145	51-61	147-174	64-77	204-252	116-122

[1]Office of the Board of Supervising Cotton Examiners.
[2]Local classing office.

generally unsatisfactory location was discouraging. Moreover, the use of the natural daylight skylight had become so much a symbol of the trade that for the most part this feeling initially hampered the use of artificial daylighting units.

Commercial firms also began to use artificial lighting for cotton classing about ten years ago. Pioneer installations were made by T. D. Truluck of the Deering Milliken Mills in Union, S. C., and since the close of World War II there has been a definite and increasing trend to class cotton under artificial daylighting. In some cases artificial daylighting proved to be so satisfactory that natural skylights were covered or entirely removed. By December 1949 more than fifteen firms in Memphis, Tenn., alone were using artificial lighting for much, and sometimes, all of their classing.

Until 1950 almost all installations were of the filtered tungsten type. However, the initial cost and operational upkeep of this type of unit, particularly in large installations, place it beyond the reach of the majority of users even though its superior technical qualifications have been proved satisfactory in practice. Nevertheless, the cotton industry was convinced that it is advantageous to class under artificial lighting, and cotton men began to look around to find a less expensive substitute.

At this point many trial installations were made. Under the direction of A. L. Smith, the Cotton Branch offices in Memphis tried out installations of luminous-indirect and louvered direct-indirect fluorescent luminaires. To their surprise, most cotton men began to realize that artificial lighting could be practical as well as possible. Most of the units tried provided so much better amount and diffusion of light than the cotton man expected of artificial lighting that often other factors were overlooked, such as the color quality of light, or the maintenance problem that precludes the use of open reflectors or fixtures in the extreme dust-catching conditions of cotton classing rooms.

Then, while technical studies were being made, but before plans by U.S.D.A. for a comparative test were started, George A. Levy of the Atlanta offices of Anderson, Clayton & Co. decided to make his own tests. His company had a new classing room under construction in Atlanta, and if a suitable way of providing artificial lighting could be found he was willing to try it out on a fairly large scale. A temporary series of different types of fluorescent units were installed and used in a practical way for several months. These Atlanta tests included rooms lighted with luminous-indirect and louvered direct-indirect fluorescent luminaires. Daylight fluorescent lamps were used, and the De Luxe Cool White was tried. To daylight fluorescent lamps blue lamps were added, with white paper used to reflect and mix the illumination until a suitable combination was found at the classing sur-

face. None of the lower color temperature lamps, even in combination, was found suitable for use in cotton classification.

Meanwhile, the manufacturer who had installed all the filtered type artificial skylights for cotton classing called Mr. Levy's attention to an enclosed examining unit which they had been marketing for some time. Originally this unit contained three daylight fluorescent tubes, two blue tubes, and six 50-100-150 watt tungsten lamps arranged on switches so that proportions of the various colors could be changed to vary the color temperature at will. Several units were supplied for trial use in Atlanta, with the suggestion that the amounts of the different lamps be varied until the illumination reached what seemed a preferred color for cotton classing use. The combination finally selected was three 40-watt fluorescent daylight lamps, two 20-watt fluorescent blue lamps, and four 25-watt tungsten filament lamps. The laboratory of a lamp company cooperated with the daylighting firm to work out the spectral distribution curves. The correlated color temperature for this combination is very close to 7500K.

Because the unit already on the market provided a mixing chamber for the different lamp colors and was an enclosed unit designed for easy maintenance in dust-filled cotton rooms, and because the manufacturer was already well acquainted with the specialized requirements of the cotton industry, and could help to maintain some degree of standardization regarding installation of this type of lighting, enough of these units were ordered to light completely the new 70 x 80-foot Atlanta classing room of Anderson, Clayton & Co. The result of illumination measurements of trial installations, made with units 6 feet above the classing table (9 feet from floor) hung from a 12-foot ceiling in rows centered at different distances, 8, 9, and 10 feet apart, are shown in Figure 1. This indicated that at 6 feet above the table units must be hung no further apart than on 8-foot centers to provide reasonably even illumination. Figure 2 shows results for a temporary installation made in an old laundry, under very bad surrounding conditions; yet when units were hung in rows 6 feet above the tables, on 8-foot centers between rows, the illumination was found to be quite satisfactory for classing. On the basis of these trial installations, the units in the new classing room were installed in rows on 8-foot centers, 6 feet above the classing table (9 feet from the floor). The result was so successful that all thought of providing an auxiliary natural skylight in the Atlanta office for buyers who might prefer natural daylighting was

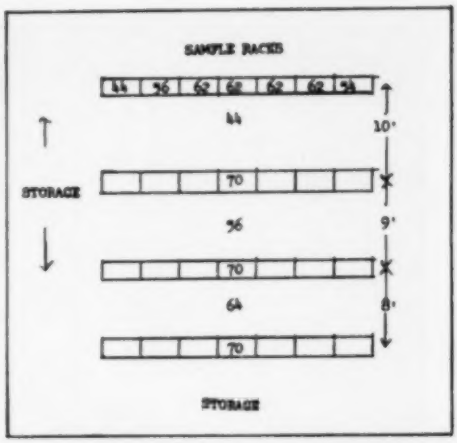

Figure 1. Illumination distribution (footcandles) under units in experimental installations, units hung on centers varying from 8 to 10 feet apart. Ceilings, 12 feet; units hung 9 feet from floor, in large open room.

abandoned. A report of approximate illumination distribution is shown in Figure 3.

Meanwhile many small installations of this type of unit were being made all over the cotton belt, so that when this first large installation was completed there were a large number of smaller ones to attest its usefulness. Other installations have since been made in the United States and in offices of foreign correspondents, so that cotton now can be classed under the same lighting in any country where cotton firms have installed it.

In the fall of 1950* an inspection trip was made with attention directed chiefly to seeing how the

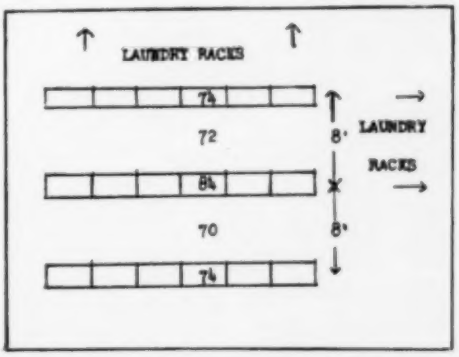

Figure 2. Illumination distribution (footcandles) under units hung in temporary installation in large old laundry. Units hung 9 feet from floor, from 12-foot concrete ceiling. Floor dark; walls dark and dirty.

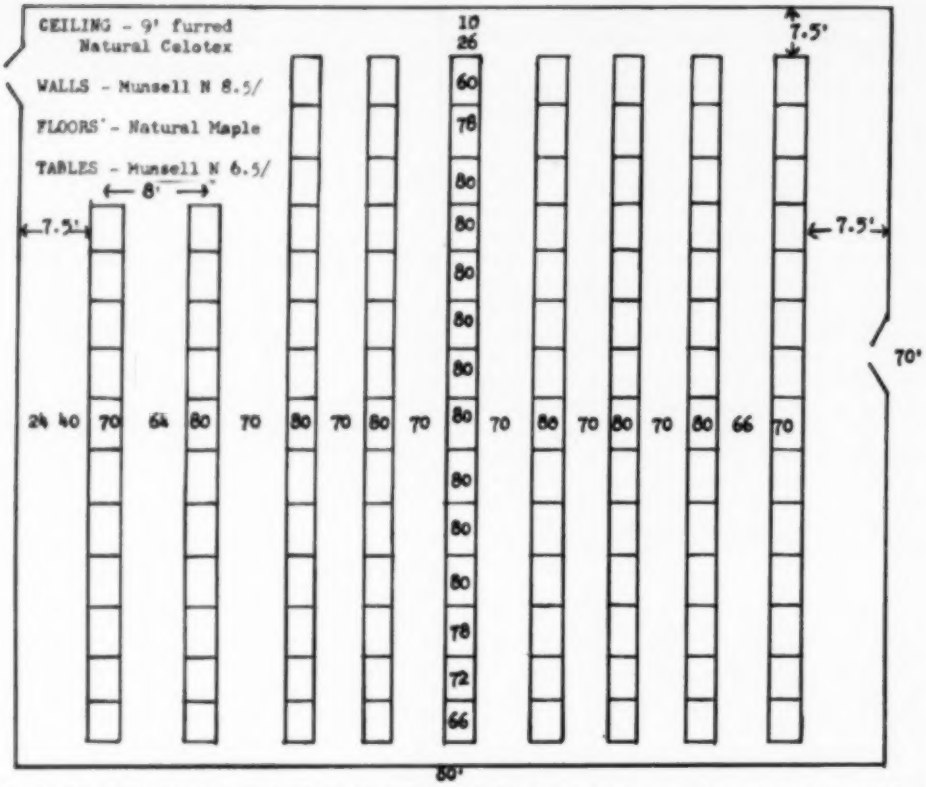

Figure 3. Illumination distribution (footcandles) of lighting installation in Anderson, Clayton & Co.'s 70 x 80-foot Atlanta classing room.

Figure 4. Anderson, Clayton & Co.'s classing room at Atlanta, the first large fluorescent type installation in a cotton-classing room.

Figure 5. A 54-foot installation of filtered tungsten daylight units at Cannon Mills, Kannapolis, N. C. Room is fully air-conditioned. A second similar installation now replaces the natural skylight at the other end of this room. Note auxiliary units for providing lighting in all parts of the room, reducing shadows and contrasts.

various installations of artificial lighting in cotton classing rooms were working out. Many installations were visited and a report was prepared containing recommendations for future installations in U.S.D.A. classing offices. A 26-page office report[5] giving details of installations, with pictures to represent a good installation of each type (see Figure 4 fluorescent-plus-tungsten, and Figure 5 for the filtered tungsten type) was thereafter prepared and circulated to all U.S.D.A. field classing offices.

Of the firms visited, practically every one using artificial lighting of the fluorescent type came up with the same findings as to amount of illumination and spacing of units. To obtain 60 to 80 footcandles the units, when set in rows, were installed no more than 8 feet between centers, and 6 feet above the classing table. There was some difference of opinion as to color of the walls, floors, ceilings, and furniture. Therefore, since there is considerable shifting of classers within the Cotton Branch, it was strongly recommended that all future Government installations be as uniform as possible, not only with regard to the type of installations, but in the surrounding conditions as indicated below:

Walls, not darker than 8.0/ Munsell and preferably 8.5/** Munsell;

Ceilings, not darker than 8.5/ Munsell and possibly 9.0/ Munsell, depending upon the height of the ceiling and structural obstructions;

Floors, about 7.0/ Munsell (but satisfactory installations may be had with a black floor);

Tables, classing tables black, although gray may be satisfactory;

Mats, on which a classer stands, should be black (so they may be used as a background for stapling).

It is important, if classification is to be kept on a constant level from office to office, that lamps be replaced with those specified for use in the unit. Since the 7500-hour expected life of the fluorescent lamps is about seven times as great as the 1000-hour rating for the tungsten lamps, they will need replacement less often. Life and color tests are to be run in our Washington laboratory in order to estimate how much change there may be with age in amount and color of illumination. On the basis of this study it is hoped that recommendations may be made for an efficient relamping schedule. It is suggested tentatively, that lamps be replaced when their lumen efficiency drops as much as 30 per cent, and that each office use a light meter to keep track of its levels of illumination. Regarding color, sufficient information is not yet available to set even a tentative figure for relamping, for we do not know how much change there will be, or how much change should be tolerated before relamping. It is known that the color of lamps from different manufacturers varies; therefore, in each installation it may be wise to replace lamps with those of the manufacturer whose lamps were used in each initial installation. As soon as further information is available on life and color tests it will be reported.

*In the summer of 1951 the author visited installations in Memphis, Dallas, and Houston. Everywhere there is enthusiasm for lighting which remains the same, June or December. Only one criticism was heard and that by a classer who objected to using artificial light and then having to go out to look at cotton in offices not equipped with it. An increasing number of cotton firms are using nothing but artificial lighting for classing. Nine classing offices of the Cotton Branch are now so equipped, and others will be equipped as they are needed.

**A paint company in Dallas, Tex., is cooperating by making a flat wall paint to meet the N 8.5/ specification. They identify this paint as a "Cotton Grading Gray."

TABLE III.—Results of Illumination Test of Cotton Examining Unit (E.T.L. Report No. 338812, November 28, 1950).

No. of Feet* from center of unit (lengthwise)	Horizontal Footcandles													
	6 Feet below Unit							5 Feet below Unit						
	Feet from center (crosswise)							Feet from center (crosswise)						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c	Ft-c
1	31.6	28.7	22.5	17.2	12.8	9.1	6.7	42.3	41.1	33.0	22.6	13.1	9.1	5.8
2	29.8	25.0	22.2	13.1	11.7	8.3	5.4	39.3	37.0	28.0	19.3	13.1	8.8	5.7
3	23.8	21.8	18.4	12.5	10.0	6.7	5.0	32.8	29.8	23.8	16.7	12.4	7.4	4.9
4	18.1	16.0	13.1	10.2	8.4	6.0	4.4	22.3	21.2	16.9	12.4	11.9	5.8	4.1
5	12.2	10.1	9.4	8.3	6.7	4.7	3.6	15.5	14.2	10.5	8.3	6.3	4.4	3.2
6	8.7	8.0	7.5	6.2	5.6	4.1	3.4	8.3	8.0	7.6	5.6	4.8	3.1	2.5
7	5.9	5.4	5.2	4.3	4.2	2.9	2.6	5.6	5.3	4.6	3.7	3.3	2.3	2.0
8	4.1	4.0	3.8	3.5	2.8	2.7	2.0	3.8	3.6	3.0	2.8	2.1	1.8	1.4

*Center of one-foot squares drawn from center of unit.

Table III gives measurements on the commercially available cotton examining unit described above. These measurements are supplied for both 6 and 5 feet below the fixture. From these data it becomes evident why three units placed end-to-end is the minimum installation advised and why rows of units, with centers not more than 8 feet apart at 6 feet from the table, must be used to provide light enough to meet specifications.

The suggestion that rows of units be placed on 8-foot centers, 6 feet above the classing tables provides a practical method for obtaining sufficient light at reasonable cost. There is no objection to placing the units on 7.5- or even 7-foot centers, or to having more illumination than 60 to 80 footcandles if one wishes to install more lighting equipment. If the surrounding conditions are well handled — the geometry of illumination and the brightness contrasts in the field of view — then one could probably go as high as 200 or more footcandles. However, installations of the filtered-tungsten type give entirely satisfactory results at

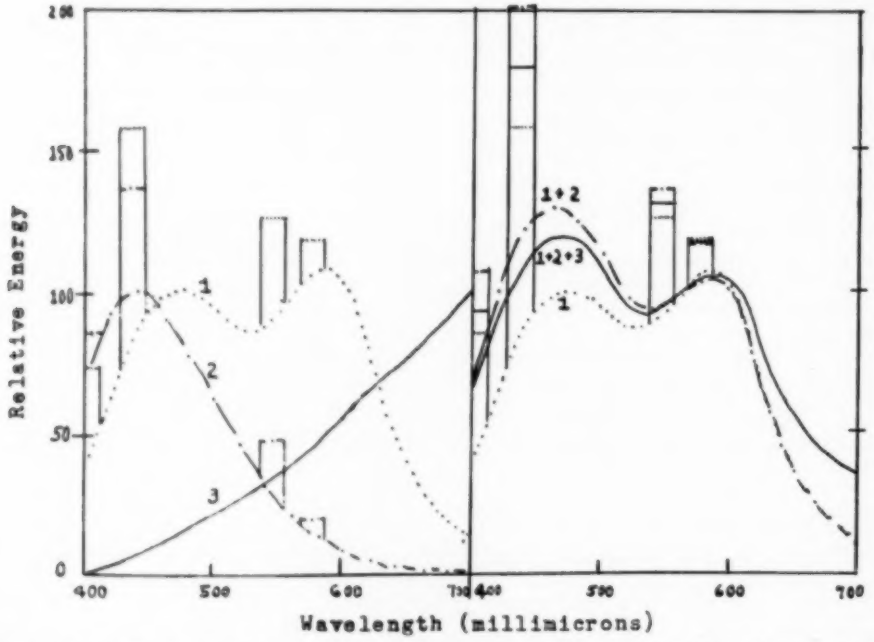

Figure 6. Spectral energy curves of separate and combined lamps used in the cotton examining unit. Curve 1: three 40-watt daylight fluorescent; Curve 2: two 20-watt blue fluorescent; Curve 3: four 25-watt silver-bowl filament lamps.

30 to 40 footcandles. This leads to the belief that the urge to use more light of the fluorescent type may be due in part to the unconscious desire for a spectral distribution closer to that of daylight. And in any case, it probably would be better to have even illumination, both vertically and horizontally nearer table height, of fairly low illumination than it would to have a high level of illumination at table height that changes rapidly in either a vertical or horizontal direction. Any good illuminating engineer can figure just what should be required in a given situation, once he knows the problem and has data similar to those shown in Tables I, II and III.

While the practical testing was going on, our laboratory had been assembling technical data, and in October 1950 a report[6] was issued in regard to certain color changes that might be expected in cotton under artificial lighting.

Typical curves for the relative spectral energy distribution (through wavelengths 400 mμ to 700 mμ, from the blue to the red end of the spectrum) in the separate and combined lamps used in the cotton examining light are shown in Figure 6. Daylight fluorescent lamps, curve 1, lack sufficient energy in both the blue and red ends of the spectrum to match that of daylight at 7500K. This lack is partially corrected in the examining light by addition of blue, as shown in curve 2, and by the red, orange, and yellow contained in the tungsten lamps, as shown in curve 3.

While it is really the spectral distribution of the illumination that is important, a shorthand description in terms of color temperature often is used to describe the color. A color temperature of 7500K seems to be one that satisfies cotton men as representing the average moderately overcast sky to the north that is preferred for color grading. A bluer light (higher color temperature) is harder on the cotton, whereas a yellower or pinker light (less blue, therefore lower in color temperature) is easier on the cotton, tending to flatter the grade. Use of the cotton grade standards for comparison tend to overcome such differences in artificial lighting, but if a cotton man thinks he has standard conditions he may not notice the difference in lighting enough to refer to the cotton grade standards as a guide in pitching this classing level. There is too much color difference in fluorescent lamps from different manufacturers to set any close color tolerance for fluorescent installations. However, if there is to be any consistency in appearance of cotton samples when a classer goes from one classing room to another, the tolerances should be at least as close as the limits of present manufacturing practices will allow.

Classers are so used to the vagaries of changing daylight that it has taken a long time for them to realize just how much variation this change in lighting has caused them in classification of samples. Although it is probable that a classer could learn to class under almost any type of a "white" light with continuous spectrum, there should be as much general standardization of artificial lighting in classing rooms as possible. He may then go from one classing room to another and find the same kind of light. Otherwise he could soon find himself in more trouble with artificial light than with changing daylight conditions.

It should be kept in mind that there is a difference between artificial *daylighting* and artificial *lighting*. Once the psychological adjustment is made toward acceptance of artificial lighting, use of a *daylighting* substitute will be found less criti-

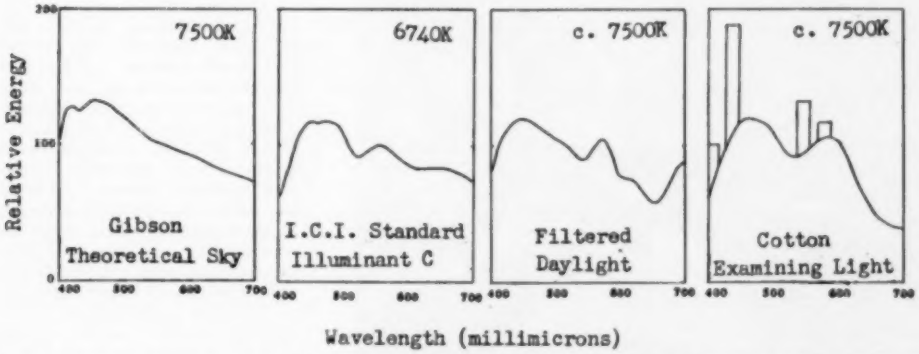

Figure 7. Relative energy curves of theoretical and actual illuminants in the daylight range near to 7500K as recommended for cotton color grading, with the international standard for average daylight—C.I.E. (formerly I.C.I.) illuminant C—shown for comparison and reference.

cal for some products than for others. When either the amount of absolute change in color, or the relative degree of change within a series of samples that can be attributed to change of illuminant, is large in relation to the size of color difference important for grading purposes, then it becomes necessary to meet increasingly rigid specifications.

The *ideal* substitute illuminant for color grading of any specified product is one under which the color and color differences that are being graded will appear the same as under the original illuminant. A *satisfactory* substitute illuminant is one under which the color and color differences are well enough duplicated to provide satisfactory grading. Each industry may have to decide for itself how close that duplication must be, and whether or not standards should be adopted to keep within that tolerance.

Therefore, while U.S.D.A. standards remain high for the artificial daylighting that we would like to have for cotton classing (see Figure 7 for curves of theoretical and real illuminants), the fairly rigid requirement this imposes — that artificial lighting for cotton classing be a close substitute in spectral as well as color quality — has been relaxed to allow use of the fluorescent-tungsten combination described. This is done to meet the need in cotton classification for a more economical unit than is supplied by artificial daylighting of the filter type. Since air conditioning must be supplied for filter-type installations if they are to be comfortable, the expense is increased beyond that which many companies are willing to meet. Requirements regarding color and amount of light may be met by use of the described combination of fluorescent and tungsten lamps. The additional requirement that the spectral distribution shall be as close as possible to daylight is more nearly met by this combination than by the fluorescent daylight lamps used alone. But the filter-and-tungsten type still provides the closest approximation available for this requirement, and the expert cotton man can see and appreciate the difference enough so that a number of them who have the artificial daylighting of filtered tungsten still prefer it for the satisfactory appearance of cotton samples, even when the illumination level may be no more than 40 foot-candles, as against a minimum of 80 for the more usual fluorescent type installation.

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A COMBINATION of recessed fluorescent and incandescent lighting is used for general illumination in the main sales area of Hermans Jewelery, Jackson, Mississippi. In the rear of the store, the low ceiling has recessed incandescent downlights with concentric louvers. Wall cases are lighted with incandescent strips. Adjustable incandescent downlights provide illumination for counter displays and for the diamond counter, the furring of the wall presented an opportunity to highlight this important sales area. Photo courtesy Mississippi Power & Light Co.

Appraisal of Discomfort Glare On Lighted Streets

By KIRK M. REID
D. A. TOENJES

IS THERE a relation between the discomfort caused by glare from street lights and the vertical footcandles incident on the eye of the motorist? If so, is the relation sufficiently definable to be useful in predicting the degree of comfort to be expected from a proposed street lighting installation? And what is the relation between discomfort and the interference with seeing caused by such glare?

Too little is known quantitatively of factors affecting discomfort glare in street lighting. Hence a program of studies of this subject has been outlined and is sponsored by the Research Subcommittee of the I.E.S. Committee on Street and Highway Lighting. The program includes both laboratory and field studies which, in later steps, approach similar conditions. The Putnam-Faucett paper[1] reports the beginning of the laboratory work. The first field studies are reported herein.

Procedure

Appraisals of discomfort glare were made while driving under 31 widely diversified street lighting installations in Cleveland. Test installations ranged in length from approximately 1000 to 4000 feet. The installations were reasonably close together; the total driving distance in an evening's "appraisal run" was approximately 25 miles. There were 10 "glare appraisers"—from Case Institute of Technology, the Nela Park Engineering Department, The Cleveland Electric Illuminating Company and the City of Cleveland. Measurements were made throughout each installation, with Taylor-Pracejus Illumination Recorder,[2] of horizontal illumination near the pavement and of vertical illumination at the eye position of a representative motorist. Street Lighting Evaluator[3] measurements of pavement brightness, obstacle brightness, and veiling glare were also made.

The 31 lighting installations are summarized in Table I. Luminaires had light distributions[4] ranging from Type I (2-way) to Type V (symmetrical). Average illumination level ranged from 0.07 to 0.97 footcandles. Mounting heights were as low as 14 feet with upright luminaires, up to 26.5 feet with pendent luminaires. Pavement surfaces included concrete, several forms of asphalt, and brick. Curb-to-curb pavement widths were 24 to 72 feet. The illuminants were filament lamps, with ratings from 2500 to 15,000 lumens.

Appraisals were made from the front seats of private cars, traveling at 20 to 25 miles an hour in the right driving lane. Drivers as well as passengers made appraisals; passengers were requested to keep their attention on the roadway as though they were driving. Appraisals were made at times when bright oncoming headlights were at a reasonable minimum. For ease of recording and charting, the comfort-discomfort glare appraisals were assigned rating numbers in accordance with the key in Table II.

Table III shows for each installation the average appraisal number and a summary of the measurements with the Illumination Recorder and the Street Lighting Evaluator.

Summary of Conclusions

1. The great majority of our street lighting is glaring, in varying degree from mildly uncomfortable to sharply uncomfortable.
2. There appears to be a general relation between comfort-discomfort appraisals and *vertical* footcandles on the eye provided *horizontal* footcandles on the pavement are taken into account as an index of field brightness.
3. Similarly, there appears to be a general relation between comfort-discomfort appraisals and Evaluator measurements of veiling glare, provided pavement and obstacle brightnesses are taken into account as an index of field brightness.
4. The results of this study hold promise that factors affecting discomfort glare in street lighting *can* be dealt with quantitatively.

Comfort-Discomfort Appraisals

One early portion of this study demonstrated that some practice is required, even with well quali-

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Engineering Dept., Lamp Div., General Electric Co., Nela Park, Cleveland, Ohio.

TABLE I.—Installation Data.

Inst. No.	Location CLEVELAND	Pavement Width	Pavement Surface (a)	Light Dist. Type	Lamp Lumens	Spacing (b)	Mounting	Overhang	Foliage Interference	Abutting Brightness (c)	Luminaires in View (d)
1	Shaw, NW of Terrace	24′	LA	I	4,000	200′OS	25′	10′	Slight	Slight	4
2	Woodworth, W of E-145	27′	LA	III	10,000	145′S	25′	6′	Slight	Slight	10
3	Shaw, W of E-128	40′	LA	III	6,000	90′S	25′	6′	None	Moderate	8
4	E-131, S of Iroquois	24′	LA	I	4,000	200′OS	25′	10′	Slight	None	5
5	E-125, N of Brackland	44′	B	III	10,000	90′S	14′	2′	Slight	Slight	10
6	E-123, S of Durant	38′	B	III	10,000	85′S	25′	6′	None	Moderate	10
7	Lakeview, SE of Chesterfield	28′	LA	III	4,000	115′OS	25′	6′	Slight	Slight	8
8	Lakeview, S of Beulah	30′	LA	III	6,000	100′OS	25′	6′	Slight	Slight	8
9	E-115, S of Wade Park	26′	LA	III	6,000	150′OS	25′	6′	Severe	None	8
10	Ashbury, W of E-110	28′	B	III	4,000	115′OS	25′	6′	Slight	None	8
11	E-110, N of Ashbury	30′	B	I	4,000	150′OS	25′	10′	Moderate	None	8
12	Superior, E of E-107	58′	OC&LA	III	10,000	90′OP	26.5′	4′	Moderate	Slight	40
13	Superior, E of Lakeview	55′	LA	IV	10,000	90′S	25′	4′	None	High	15
14	E-110, N of St. Clair	49′	LA&B	III	6,000	135′S	25′	6′	Slight	None	10
15	St. Clair, SW of E-66	50′	B&LA	III (e)	10,000	125′OP	16′	−2′	Slight	Slight	30
16	St. Clair, SW of E-70	72′	B&LA	IV	10,000	120′OP	25′	4′	None	High	40
17	St. Clair, SW of E-40	60′	B	III	10,000	125′OP	25′	4′	None	Moderate	30
18	Hamilton, NE of E-40	38′	B	III	6,000	125′OS	25′	6′	None	Slight	20
19	Superior, E of E-65	50′	B&LA	III (e)	10,000	100′OP	16′	−2′	Slight	Moderate	20
20	E-79, N of Superior	40′	B	III	10,000	125′S	25′	6′	Slight	Moderate	25
21	E-79, S of Star	24′	OC	I	6,000	215′OS	25′	10′	Slight	Slight	10
22	E-71, S of Lexington	30′	LA	III	6,000	115′OS	25′	6′	Slight	Slight	8
23	E-70, N of Chester	30′	DA	I	4,000	185′OS	25′	10′	Slight	Slight	6
24	Linwood, W of E-65	30′	B	III	4,000	120′OS	25′	6′	Severe	Slight	6
25	Whittier, E of E-55	30′	B	I	4,000	160′OS	25′	10′	Severe	Slight	6
26	E-71, S of Cedar	34′	LA	V (e)	2,500	155′S	14′	−2′	Slight	Slight	8
27	Cedar, E of E-71	42′	LA	II	10,000	90′S	25′	2′	None	Moderate	40
28	E-79, S of Cedar	30′	LA	III	6,000	115′OS	25′	6′	Moderate	Slight	10
29	Quincy, W of E-55	60′	OC	III	10,000	100′S	25′	4′	None	Slight	10
30	Woodland, E of E-37	55′	LA	IV	10,000	105′OP	26.5′	4′	None	High	50
31	Woodland, E of E-67	48′	LA	III	10,000	95′OP	26.5′	4′	None	Slight	50

(a) Pavement Surface: OC—old concrete; DA—dark asphalt; LA—light asphalt; B—brick;
OC & LA—old concrete center and light-asphalt sides;
B & LA—brick center and light-asphalt sides;
LA & B—light-asphalt center and brick sides.
(b) Spacing: S—staggered; OP—opposite; OS—one side.
(c) General brightness level of signs, show windows, service stations, etc.
(d) Approximate number of luminaires in field of view of appraisers.
(e) Upright.

fied observers, to obtain reasonably consistent comfort-discomfort appraisals. Members of the Committee on Street and Highway Lighting made appraisals during a meeting in Detroit. However, the seven test installations proved to be too few in number, and distances between them were found to be too large. Further, conditions were adverse for appraisals during one evening. The results were not sufficiently consistent to warrant charting. Nevertheless the experience gained and the comments made by Committee members were most valuable in carrying out the subsequent studies in Cleveland.

In Cleveland the observers were reasonably uniform in their comfort-discomfort appraisals of most of the 31 installations. Appraisals with more than average spread in their rating numbers were mostly of installations where a judgment was made difficult by low illumination level or foliage interference.

TABLE II.—Comfort-Discomfort Appraisal Rating Numbers.

Pleasant — not noticeable as glare	1
Barely comfortable	2
Borderline between comfort and discomfort	3
Mildly uncomfortable	4
Uncomfortable	5
Sharply uncomfortable	6
Intolerable	7

No installation received a *collective* appraisal as favorable as "borderline between comfort and discomfort." The average of all installations was on the "uncomfortable" side of "mildly uncomfortable." Several installations — some modern and others obsolete — were in the "sharply uncomfortable" range.

The appraisals of some observers showed them to be more sensitive than others to street lighting glare. The same has been found true in comfort-discomfort appraisals of interior lighting.[5] and in studies under laboratory conditions.[6] It may well be contended that standards of good practice in street lighting should aim toward comfort for the more sensitive rather than simply for the average observers.

TABLE III.—Summary of Appraisals and Measurements.

Inst. No.	Average Comfort-Discomfort Appraisal	Footcandles			Footlamberts (Evaluator Data)			
		Average Horizontal	Average Vertical	Maximum Vertical	Average Veiling Glare	Maximum Veiling Glare	Average Pavement Brightness	Average Obstacle Brightness
1	3.7	0.26	0.018	0.030	0.034	0.056	0.070	0.005
2	4.2	0.56	0.046	0.083	0.043	0.054	0.23	0.042
3	4.2	0.70	0.093	0.13	0.090	0.13	0.39	0.038
4	4.2	0.31	0.012	0.030	0.018	0.036	0.098	0.020
5*	4.4	0.21	0.050	0.089	0.032	0.037	0.078	0.041
6	3.5	0.77	0.073	0.10	0.043	0.055	0.38	0.035
7	3.9	0.32	0.039	0.076	0.039	0.053	0.16	0.026
8	4.0	0.52	0.047	0.088	0.036	0.054	0.16	0.021
9	4.6	0.44	0.036	0.085	0.060	0.14	0.19	0.032
10	3.8	0.33	0.021	0.039	0.020	0.032	0.063	0.014
11	3.4	0.30	0.015	0.032	0.026	0.032	0.057	0.012
12	3.2	0.73	0.068	0.10	0.047	0.057	0.27	0.041
13	5.4	0.54	0.18	0.29	0.12	0.25	0.23	0.018
14	3.2	0.31	0.049	0.096	0.024	0.036	0.071	0.028
15	5.0	0.34	0.092	0.16	0.048	0.060	0.17	0.029
16	3.6	0.60	0.13	0.20	0.058	0.078	0.30	0.053
17	3.7	0.66	0.10	0.15	0.038	0.046	0.25	0.059
18	4.6	0.47	0.068	0.13	0.052	0.072	0.14	0.024
19	4.5	0.73	0.12	0.17	0.067	0.080	0.27	0.017
20	4.4	0.71	0.11	0.24	0.069	0.12	0.30	0.076
21*	6.0	0.17	0.052	0.20	0.034	0.050	0.11	0.019
22	3.8	0.36	0.032	0.091	0.020	0.024	0.067	0.018
23*	5.1	0.19	0.043	0.11	0.028	0.052	0.04	0.012
24	3.2	0.33	0.025	0.039	0.026	0.039	0.065	0.018
25	5.7	0.26	0.040	0.083	0.032	0.038	0.11	0.010
26*	4.4	0.07	0.030	0.056	0.023	0.040	0.034	0.003
27	5.8	0.73	0.12	0.17	0.041	0.060	0.19	0.046
28	4.7	0.43	0.071	0.13	0.041	0.071	0.11	0.029
29	4.6	0.46	0.093	0.21	0.027	0.037	0.17	0.038
30	4.6	0.97	0.24	0.34	0.062	0.090	0.41	0.18
31	3.6	0.87	0.092	0.14	0.038	0.046	0.26	0.042

*Classified as local traffic because of low illumination or wide spacing.

Several observers commented that they found it difficult to form purely subjective judgments. They particularly doubted the consistency of their appraisals of the first few installations. The authors would have preferred to discard all first-night appraisals, asking each observer to come back for a second night. Unfortunately, most of the observers could not do so. Instead, by inspection of 31 diversified test installations in one evening, any inconsistencies in judgment of the first few installations were outweighed by the later appraisals.

Effects of Source and Field Brightness

Several investigators[1, 6, 7, 8, 9] have found that discomfort varies with *source* brightness to the first power, other conditions being constant. In this study the measured values of vertical footcandles and veiling glare are closely related to the collective brightness of the street lights in the field of view of the motorist. Hence these quantities are plotted to the first power.

Luckiesh and Moss have summarized and reported the work of a number of investigators[9] showing that discomfort varies inversely with the *field* brightness to a fractional power. For the range of source size in typical street lighting practice, Putnam and Faucett[1] found an exponent of approximately 0.3. This is in agreement with the summary by Luckiesh and Moss. Hence an exponent of 0.3 may be considered to give proper weight to field brightness.

This 0.3 exponent is applied to two values which are used in the accompanying chart as the best available indices of general field brightness. One is the average horizontal footcandles on the pavement. The other is a weighted field brightness, as explained later.

Charting by Appraisal Number

Not many appraisers considered that the test installations called for use of the extreme rating numbers of 1 and 7, meaning "pleasant" and "intolerable," respectively. Numbers 2 and 6—"barely comfortable" and "sharply uncomfortable"—appeared more often. Moderate ratings of 3, 4, and 5 were used more frequently. With this unequal distribution, it is a proper question: For *each* of the rating numbers, what were the average conditions? Figs. 1 and 2 give answers, based on the 27 arterial test installations in Cleveland.

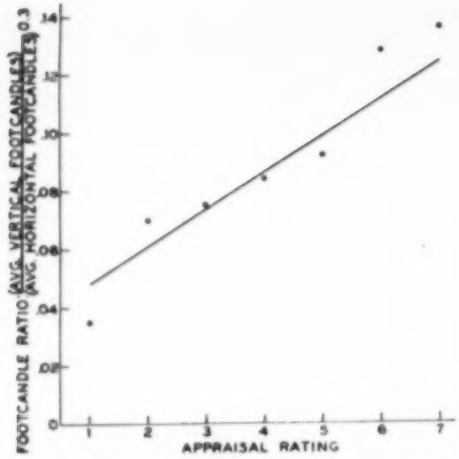

Figure 1. Cleveland arterial test streets. *Averages* of the footcandle ratios for *each individual* comfort-discomfort appraisal rating number, shown as a function of the appraisal rating numbers.

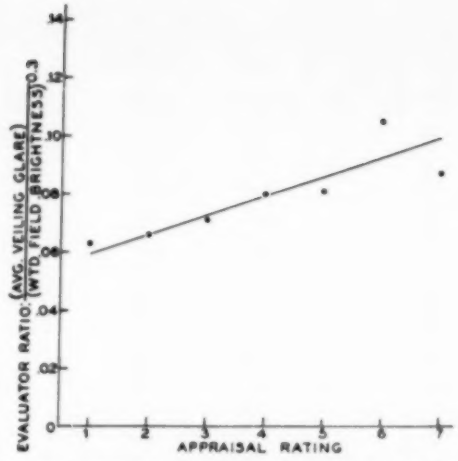

Figure 2. Cleveland arterial test streets. *Averages* of the Evaluator ratios for *each individual* appraisal rating number, shown as a function of the appraisal rating numbers.

In Fig. 1 there is one plotted point for each appraisal number. The ordinate of each point is a footcandle ratio. The numerator of the ratio is the average vertical footcandles on the motorist's eye, and the denominator is the average horizontal footcandles on the pavement raised to the 0.3 power.

Fig. 2 differs from Fig. 1 in that the ordinate of each point is a similar ratio based on Evaluator measurements. Its numerator is the average veiling glare, and its denominator is the weighted field brightness raised to the 0.3 power. The weighted field brightness,[10] determined from the Evaluator measurements, is the sum of 70 per cent of the average pavement brightness and 30 per cent of the average obstacle brightness.

The slopes of these two curves indicate the substantial gain in lighting comfort which is achieved, other conditions being equal, when the illumination

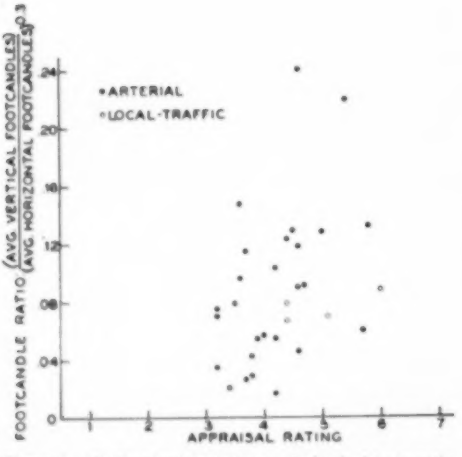

Figure 3. All Cleveland test streets. *Individual* footcandle ratios, shown as a function of the *averages* of the appraisal rating numbers for each installation.

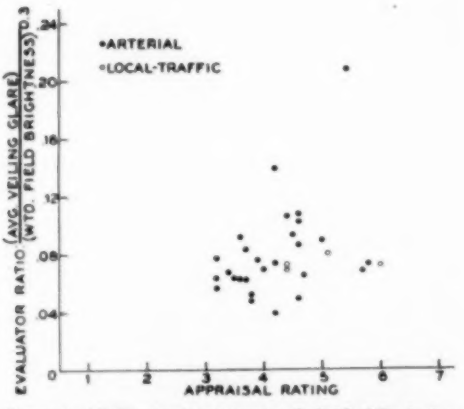

Figure 4. All Cleveland test streets. *Individual* Evaluator ratios, shown as a function of the *averages* of the appraisal rating numbers for each installation.

(or glare effect) on the eye is reduced in relation to the general brightness of the field.

The plotted points in Figs. 1 and 2 do not represent equal numbers of appraisal ratings, as has been explained. This weighting was taken into account in the computations to find the most representative straight lines to pass through the points on the two charts.

The "correlation coefficient" has been calculated for these data. There is less than 1 chance in 100 that this degree of correlation would have arisen if the two variables were not actually correlated.

Charting by Installation

In Figs. 3 and 4 there is one plotted point for each of the installations studied. The abscissae and ordinates are the same as those in Figs. 1 and 2, respectively. The points in Figs. 3 and 4 are too scattered to warrant plotting smooth curves through them. Nevertheless, certain comments may be offered:

a. Some installations with similar footcandle and Evaluator ratios had substantially different average appraisals. This indicates that factors in addition to those ratios probably affect the degree of comfort. For example, differences in distribution of brightness over the luminaires are not shown in either the footcandle or Evaluator ratios. And these ratios may not take adequately into account the effect of distant luminaires which in some instances may be relatively close to the line of sight and in other instances may be masked by foliage.

b. Each point in Figs. 3 and 4 represents 10 individual appraisals, whereas each point in Figs. 1 and 2 represents, on the average, almost 40 individual appraisals. The better alignment of the points in Figs. 1 and 2 may be due largely to the greater number of observations averaged in each point. Additional appraisals by the same observers, with the attendant additional practice in appraising, would be expected to reduce the scattering in Figs. 3 and 4.

c. The installations classified as local-traffic lighting—taken to be those below 0.25 average horizontal footcandles—fall within a limited area on each chart. They are all on the right-hand (discomfort) side of the general spread of the points. This position indicates that they were appraised as being less comfortable than arterial-traffic installations of similar ratios. This might be expected because of the generally long spacings and use of luminaires designed to emit relatively high candlepower at angles near the horizontal.

Acknowledgments

The authors are indebted to H. H. Magdsick, S. K. Guth, and Ward Harrison for consultation in planning the study and analysis of the data, to W. J. Sojeba, G. W. Izant, F. H. Bollens, and G. K. Glass for selection of test streets and for data on the lighting installations, to W. G. Pracejus and E. T. Leppelmeier for measurements with the Illumination Recorder, to R. E. Birr for assistance with the Evaluator measurements, and particularly to the observers who made the appraisals.

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DISCUSSION

LOUIS J. SCHRENK*: Mr. Kirk Reid and Mr. D. A. Toenjes should be congratulated on their work with discomfort glare. They have taken a maze of data which seemingly is inconsistent in many details and have correlated it and come up with four general conclusions which are sound and logical. The difficulty of arriving at the proper relation between discomfort glare and its related factors is a matter of accurate and reliable observations. Discomfort glare is an abstract sort of thing. It is a form of glare, but so is tolerable and intolerable glare. Present day street lighting installations are inherently a glare source to some degree. I feel that the observers are not appraising the same facts. Some, and I think a great many, are prone to begin discomfort glare where tolerable glare for that particular installation leaves off, although discomfort to the eye exists before this point is reached. In order to evaluate this discomfort glare and its relation to the other factors a better understanding of just what discomfort glare is should be established.

RICHARD E. SIMPSON**: Quick and clear appraisal of the hazards present in modern traffic is a prime essential from a safety viewpoint. Therefore, the first conclusion drawn from the paper viz: "The great majority of our street lighting is glaring, in varying degree from mildly uncomfortable to sharply uncomfortable" presents a factor of considerable importance in the public safety field. Inasmuch as glare tends to reduce visibility it automatically tends to reduce or slow down quick and clear perception of hazards.

*Public Lighting Commission, Detroit, Mich.

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Some support to this statement is found in the results of a study made a dozen years ago on the relation of mounting height of street lights and the night fatality rate. It was found that as the mounting height decreased the night fatality rate increased, and that the highest night fatality rate was recorded on two streets with a low mounting height of 16 feet. The illumination level on these two streets was low and the majority of the fatalities involved pedestrians, a hard to see object. There is then some logic in assuming that the contrast caused by a combination of low level of street lighting and low mounting heights of luminaires creates low visibility and therefore a dangerous traffic condition.

KIRK M. REID and D. A. TOENJES*: As Mr. Schrenk has indicated, a subjective appraisal, such as that of comfort and discomfort, lacks the clearly defined scale and the precision the engineer would like to have. It was our experience, however, that the various observers formed such judgments with greater assurance and ease as they proceeded through the tests. With a little practice it became easier to dissociate the matter of comfort from other factors, such as visibility. One must not forget that there is an actual difference in the degree of discomfort which various people experience under a given set of conditions.

*Authors.

An Analysis of Fluorescent Luminaire Brightness

Additional Discussion and Rebuttal on Paper by John J. Neidhart

(Published November 1951 ILLUMINATING ENGINEERING, pp. 569-576)

R. D. BRADLEY*: First, I think that we are all in agreement that maximum brightness data, as it is now taken is far from a satisfactory criteria of luminaire performance for comfort. First, I think we must determine that the only reason we object to brightness, or wish to know brightness values is to have some indication of the comfort of the equipment under the actual conditions of usage.

The fallacies in measuring brightnesses as performed today, of course, are quite well known to most people doing lighting engineering work. Your discussion of methods of obtaining average brightnesses are, undoubtedly, much more accurate than the present methods of obtaining intrinsic brightnesses over a given area.

In my opinion, neither system of measuring brightnesses is the answer to any of our pertinent glare problems of today. It is true that the average brightness method has more accuracy in its favor, but again is disassociated from the use of the equipment.

My experience in trying to use any brightness tabulation is that it is only roughly indicative of what might be expected from the equipment under certain predetermined conditions.

I have devoted considerable time and study to Ward Harrison's glare factors, and as you may know, average brightness calculations are made as part of this calculation for glare ratings. Practically the same work is done as is outlined in your paper. This, however, in the glare rating study is only one part of the calculations, and is later associated with such things as room brightnesses, created by certain reflection factors: walls, ceiling, work surfaces, and so forth. I think the thing that we are all interested in is comfort. You cannot draw any rules for comfort on any form of brightness reading alone. The luminaire location must be known as must a great many other things concerning its usage, before any criteria of comfort can be assigned to its usage.

It is my feeling that eventually the lighting art will progress to a point where such things as intrinsic or average brightnesses will not be recorded, but a completed calculation will be done to give some definite glare rating or comfort rating under certain specified conditions.

I think that the paper is very well done, and the data is checked with a great deal of care; however, it is the ultimate usage of such data that leaves me in a quandry.

JOHN J. NEIDHART*: Although Mr. Bradley's point that luminaire brightness alone is not a true criterion of the degree of comfort that may be expected from an installation is quite true, it does not follow that luminaire brightness is of little value. In its simplest usage, it offers a means of determining the *relative* comfort that may be expected from installations of different luminaires having similar photometric distribution characteristics. Average brightness data is an even more valuable tool to the experienced lighting engineer, for he may use this data in combination with known or recommended room surface reflectances, the size of the room, the illumination level to be expected, and the distribution characteristics of the luminaire to obtain a reasonable approximation of a glare rating without going through all the calculations. For example, he knows that the luminaire brightness at high angles is much more important in large rooms than in small rooms; he realizes that a somewhat higher luminaire brightness can be tolerated if the luminaire distribution is such that it will illuminate the background against which it may be seen; and where reflected glare is apt to be a problem, he knows that he must select a luminaire with low average brightness in the reflected glare zone.

It is quite possible that by means of calculations and experience we will eventually be able to establish sets of valid brightness limitations on luminaires to ensure seeing comfort for various room sizes and other pertinent conditions. In the meantime, let us start using the average brightness data that goes hand in hand with the comfort evaluation systems that have been developed.

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*Author, Westinghouse Electric Corp., Cleveland, Ohio.

Electrical Design Data for Mercury Vapor Lamp Circuits

By C. H. BURNS
C. A. FREEMAN
D. W. ROWTEN

MERCURY vapor lamps belong to the general classification known as electrical discharge lamps, in which light is produced by the passage of an electrical current through a vapor or gas, rather than through a tungsten wire.

The fundamental advantages of the mercury vapor light source are long lamp life and a high luminous efficiency with a high light output per unit which reduces the required number of luminaires to a minimum for a given application.

In the application of the mercury vapor lamp many operating problems have developed that may not be generally understood. The following discussion is devoted to a better understanding of mercury vapor lamps and circuits and the effect of the many variables that may be introduced into the circuit and control devices.

Types of Mercury Vapor Lamps

There are five types of mercury vapor lamps that are particularly well adapted to lighting application — the 100-watt A-H4 and K-H4, the 250-watt C-H5 and A-H5, the 400-watt A-H1, B-H1, E-H1 and J-H1, the 1000-watt A-H12 and the 3000-watt A-H9.

The lighting lamps differ widely in physical appearance as shown by Fig. 1, even though their basic principles of operation are similar.

The Operating Characteristics

To start and operate any of the mercury vapor lamps on a standard electrical circuit (whether series or multiple), a ballast is required.

A ballast is generally described as an auxiliary device used with vapor lamps to provide proper operating characteristics. It may perform one or more of the following functions: Transform current or voltage, or limit current.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Westinghouse Electric Corp., Cleveland, Ohio and Bloomfield, N. J.

Effect of Ambient Temperature on Lamp Starting

Ambient temperature affects the striking voltage of all discharge lamps to some extent, regardless of the circuit used to start and control the lamps. As the temperature is lowered, a higher open circuit voltage is required to start the lamp. The open circuit voltages recommended by the manufacturer are adequate to provide reliable starting for most indoor applications.

The open circuit voltage required to start the A-H1, B-H1, C-H5 and K-H4 lamps increases rather slowly with decreasing temperatures. Consequently, for these lamps it is not economically feasible to manufacture indoor ballasts with open circuit voltages different from those for cold weather operation. For these lamps, the starting voltages supplied by available ballasts are adequate for temperatures down to −30°F.

The single bulb A-H9 lamp is critically affected by low temperatures and drafts and is not considered suitable for use below +32°F. without special protection.

The open circuit voltage required to start the E-H1, J-H1 and A-H12 lamps increases rather rapidly with decreasing temperatures. Therefore, it is necessary to use higher open circuit voltages to insure starting at lower temperatures. The industrial type ballasts are, in general, limited to indoor use. For outdoor applications, ballasts with considerably higher voltages are available for the E-H1 and J-H1 lamps to insure starting down to approximately −30°F. As yet, no ballasts are available for cold weather starting of the A-H12 lamp.

The relation of ambient temperature and open circuit voltage for reliable starting for a ballast test with E-H1 lamps is illustrated in Fig. 2.

Allowance has been made in selecting design open circuit voltages for low line voltage on the ballast, and variation in lamps and ballasts. Consequently, it may be possible to operate installations at temperatures well below the recommended minimum values if slow starting and an occasional lamp failing to start are not objectionable.

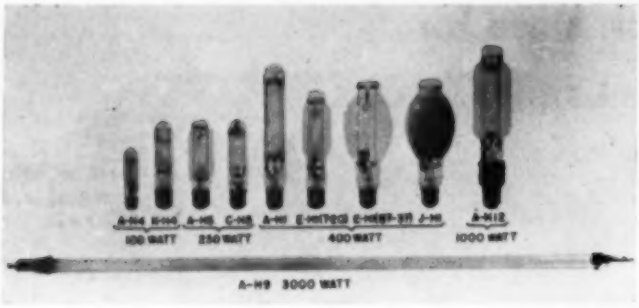


Figure 1. Mercury vapor lamps for lighting service.

The ambient temperature at the ballast location does not affect starting of the lamp since the ballast has relatively constant open circuit voltage over a wide range of temperature sufficient to initiate the initial arc through the ionization of the gases. However, at low temperatures with the series capacitor type ballast, the lamp may require a longer period of time to reach stable operation than if used on a high reactance inductive type ballast. This additional time interval is required because low temperature affects the capacitance of the capacitor, which in turn reduces the lamp current.

Auxiliary Equipment for Multiple Circuits

In the multiple circuit a ballast is customarily used to limit the current. The ballast is designed to operate a normal lamp at its proper starting and operating characteristics. Generally, these ballasts are power factor corrected.

Ballast

All ballasts for use on multiple systems must of course be designed for the proper voltage and frequency of the supply with which they are to be used.

Most ballasts use a high reactance transformer to provide starting voltage and to limit current. A typical power factor corrected circuit of this type is shown in Fig. 3.

Another power factor corrected circuit which has been used extensively in ballast design has the capacitor in series with the reactor and has an air-gap in the magnetic core as shown in Fig. 4.

For higher circuit voltages a tapped reactor as shown in Fig. 5 is often used, especially where power factor correction is not required.

A common two-lamp ballast circuit for mercury lamps uses the lead-lag principle similar to the two-lamp lead-lag fluorescent ballasts. This mercury ballast (circuit shown on Fig. 6) consists of a common autotransformer with one lamp in series with a capacitor and reactor and the other in series with a reactor. The current is leading in the first lamp and lagging in the other lamp, resulting in a combined line power factor of 95 to 99 per cent. The out-of-phase lamp currents also are helpful in minimizing stroboscopic effect.

The lagging lamp on a two-lamp ballast comes up to full output in the same time as on a single-lamp ballast. However, the leading lamp is slower, requiring from 20 to 40 minutes with the 400-watt A-H1 lamp, and approximately 10 minutes for other types which have more compact arc tubes. This results from the lower ratio of starting current to operating current on the leading leg of the ballast. At very low temperature the A-H1 lamp on the leading leg may never reach full brightness,

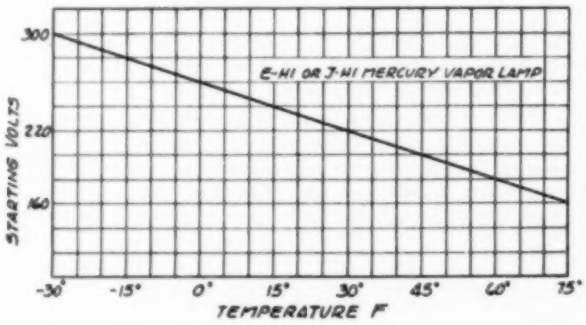


Figure 2. Relation of starting volts to temperature.

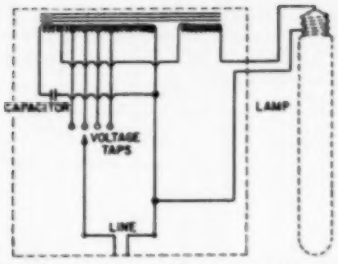


Figure 3. High reactance ballast power factor corrected.

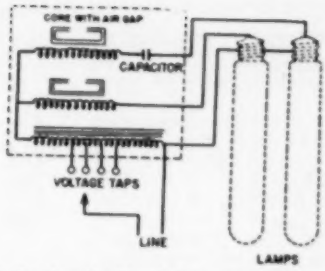


Figure 6. Two-lamp lead-lag ballast power factor corrected.

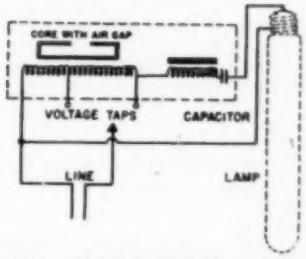


Figure 4. Series capacitor ballast power factor corrected.

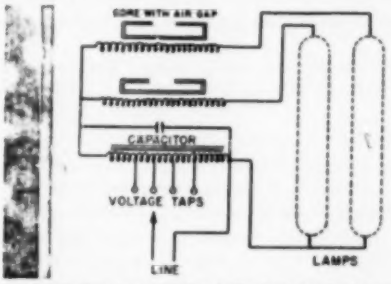


Figure 7. Two-lamp lag-lag ballast power factor corrected.

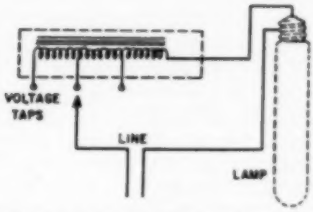


Figure 5. Simple reactor ballast low power factor.

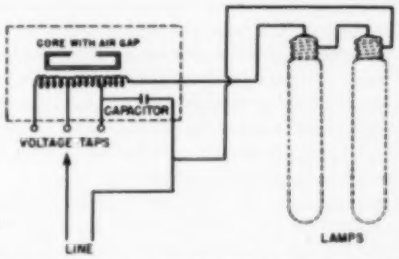


Figure 8. Two-lamp series reactor ballast power factor corrected.

and is therefore not recommended for low temperature operation with these ballasts.

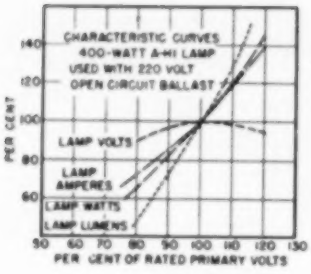
Another two-lamp ballast circuit consists of a common autotransformer, two lagging reactors and a multiple capacitor for power factor correction (Fig. 7). This circuit has been used for the A-H9, 3000-watt lamp and has electrical characteristics similar to the single-lamp high power factor ballast.

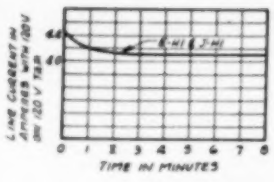
A third two-lamp circuit (Fig. 8) operates two mercury lamps in series with a single reactor and has a capacitor across the line for power factor correction. This circuit depends upon sufficient line voltage for starting and is therefore most practical on 460-volt distribution systems. The A-H1, E-H1 and J-H1 400-watt lamps and the A-H12, 1000-watt lamp can be operated at indoor temperatures from such a circuit. This circuit requires the least amount of material per lamp and is therefore low in cost. Of course, its main disadvantage is that the failure of one lamp will extinguish two light sources, and the maintenance man will not know which lamp has failed. Also, wiring may be somewhat complicated.

Other circuits, including pulse type starting or resonant circuits, have been used for special lamps and special applications.

Voltage Considerations

To provide for a variation from the nominal voltage of the system, each ballast may be provided with taps. For normal lumen output, wattage consumption, dependable starting and good lamp life, the line should be connected to the tap nearest the





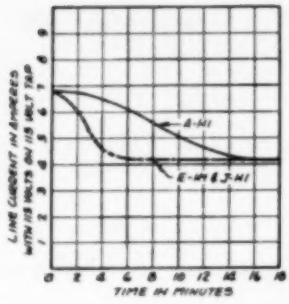


Figure 9. (Left) Relation of voltage, current, power, and lumens.

Figure 10. (Center) Line current *vs* time. High-reactance 120/420 volt primary ballast designed to provide 300 volts open circuit.

Figure 11. (Right) Line current *vs* time. High-reactance 115-volt primary ballast designed to provide 220-volt open circuit.

actual line voltage (measured when all lamps and other loads on the circuit are energized). If primary voltage varies from the rated voltage of the ballast, lamp voltage, current, wattage and light output will vary. Fig. 9 shows this variation for an A-HI lamp on a standard industrial type ballast with 220 volts open circuit voltage.

Momentary line voltage dips of 15 to 30 per cent (depending on the type of ballast), below normal can be encountered without causing a lamp outage. The ratio of open circuit voltage of the ballast to the lamp operating voltage determines in part the permissible line voltage dip which can be tolerated without lamp outage. The higher this ratio, the greater is the permissible voltage dip.

The lead lamp on a two-lamp lead-lag circuit, Fig. 6, or a single-lamp on a series capacitor type circuit, Fig. 4, will stand a greater voltage dip than will the lag lamp on a circuit with comparable open circuit voltage.

Power interruptions of more than a few cycles duration will cause lamp outage; however, these interruptions are usually infrequent.

Frequency

Most equipment is designed for a frequency of 60 cycles. Operation of the lamps on lower frequencies down to 40 cycles is possible, although the transformers are larger and stroboscopic effect is greater. Since the arc is actually extinguished each time the current reverses, at frequencies below 40 cycles the mercury vapor sometimes deionizes between cycles and the electrodes cool sufficiently to prevent restriking of the arc. Operation on frequencies lower than 40 cycles is not recommended although some mercury vapor lamp installations have been made utilizing a 25-cycle, three-phase source. The use of three-phase power reduces the stroboscopic effect considerably.

Circuit Protection

As mentioned previously, the starting and operating characteristics of the mercury vapor lamp, which requires a ballast for its operation, are quite different from those of the incandescent lamp. The line starting current for each type lamp and ballast varies in maximum value as well as in duration. It may vary from less than normal to 75 per cent greater than normal for different lamp and ballast combinations. Figs. 10, 11 and 12 show the variation of input current to the ballast with time for different types of ballasts.

In general, the higher the ratio of secondary short circuit current to lamp operating current, the shorter is the lamp starting time for a given type of lamp. The high pressure short arc lamps will usually reach stable operating conditions faster than the longer arc lamps.

Line currents and other technical data on the

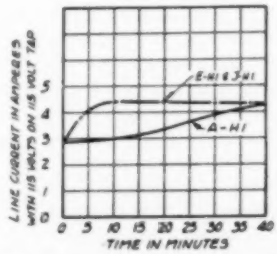


Figure 12. Line current *vs* time. Series capacitor 115/230 volt primary ballast designed to provide 220-volt open circuit.

TABLE I.—Ballast Operating Characteristics.

Ballast	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. Series Capacitor	H.P.F. Lead-Lag 2-Lamp	L.P.F. Reactor	H.P.F. High Reactance	H.P.F. High Reactance	H.P.F. Lag-Lag 3-Lamp
Circuit Fig. No.	3	3	3	4	6	5	3	3	7
Type of Lamp	C-H5	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	E-H1 J-H1 A-H1	A-H12	A-H12	A-H9	A-H9
Rated Lamp Watts	250	400	400	400	800	1000	1000	3000	6000
Approx. Line Watts	292	447	440	440	855	1036	1085	3165	6280
Line Voltage	120	120	115	115	115	230	120	230	230
Ballast Open Circuit Voltage	250	300	220	220	220	230	220	850	850
Approx. Line P.F. (%)	94	92	90–95	90–95	90–95	63	Over 90	90–95	90–95
NORMAL OPERATION									
Line Current (Amps.)	2.7	4.1	4.2	4.3	7.6	8.2	10.4	15.	30.
STARTING									
Line Current (Amps.)	3.4	4.4	6.8	2.9	4.5	12.	14.3	21.	42.
OPEN CIRCUIT									
Line Current (Amps.) Following a lamp failure or power interruption	2.7	6.6	4.3	3.4	1.5	0	10.6	15.4	29.6

more common ballasts and lamp combinations are shown in Table I.

The two-lamp (lead-lag type) ballast has a starting current that is actually less than normal operating current and it builds up to full current in about twenty to twenty-five minutes in the case of the 220-volt open circuit ballast with A-H1 lamps.

Thermal-magnetic or thermal time-delay type of circuit breakers should always be used, since instantaneous magnetic type breakers may trip out due to the short duration transient line current sometime present when circuit is energized. Fuses may be used but should have characteristics similar to the breaker characteristics shown in Figs. 13 and 14.

Breakers should always be derated in accordance with the manufacturer's recommendations to allow for ambient temperatures of breaker enclosures. For panelboard applications the protective device rating should be not less than 142 per cent of the normal line current. For individually enclosed breakers the rating should be not less than 125 per cent of the normal line current.

Figs. 13 and 14 show typical characteristics of thermal-magnetic and thermal breakers suitable for use with mercury vapor lamp ballasts. Superimposed on these curves are shown typical curves of input line current versus time as previously shown in Figs. 10 and 11. The relation of these curves may be helpful in selecting a breaker of the correct size.

The thermal-magnetic type breaker is ideally suited for most mercury vapor lighting applications. It is a medium cost unit that can be used for both switching and protection.

The thermal type breaker of the quick-make and quick-break type is suitable for medium duty service and may be used for switching and protection.

Light duty thermal type breakers of the slow-make and slow-break type are low in cost but not generally recommended for switching of mercury vapor loads.

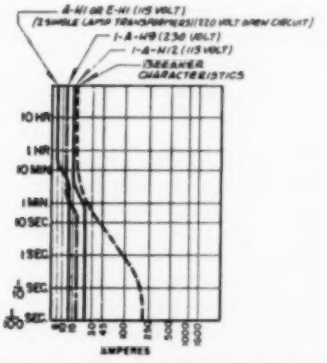


Figure 13. Time current characteristics of mercury vapor lamps on thermal magnetic type breakers.

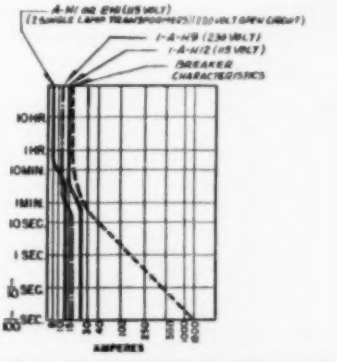


Figure 14. Time current characteristics of mercury vapor lamps on thermal type breakers.

As a further aid in selecting breakers for mercury lighting circuits reference may be made to Table II.

The high reactance autotransformer types of multiple ballast shown in Fig. 3 sometimes have a short duration transient line current of, roughly, three or four times normal current upon closing the circuit. Since these transients are only a few cycles in duration they do not influence breaker ratings provided thermal or thermal-magnetic breakers are used.

On the ballasts where the power factor correction capacitor is effectively across the line when the circuit is energized, Figs. 3, 7 and 8, the line current of the ballast may be greater than normal when a lamp fails or following a power interruption when the lamp is still too hot to restart. The line current will continue at this increased value until the lamps have been replaced or have cooled sufficiently to restart (approximately 5 minutes), after which the lamp and ballast will follow the normal starting cycle.

These line current characteristics should be recognized when selecting circuit protection. Circuit breakers or fuses should have adequate capacity for starting and open circuit line currents.

Auxiliary Equipment for Series Circuits

In the series street lighting circuit the current limiting device is the constant current transformer used to regulate the current flowing in the series circuit.

In a series lighting circuit a fundamental requirement is that the current in the circuit be constant at all times, so that normal lumen output is obtained from all lamps regardless of individual lamp outages or failures. This means that the voltage supply must be variable and dependent on the number and size of lamps in the circuit. To meet these requirements, a constant current transformer of the moving coil type is used. These are commonly called constant current regulators.

Since the mercury lamps available do not have operating currents matching the usual regulator secondary circuits and for other reasons discussed below, it is usually necessary to use individual lamp ballasts when operating mercury vapor lamps from a series circuit.

Ballasts

The ballast or transformer required for the operation of a single mercury lamp from a series circuit differs in design from the more common multiple type of ballast. The usual design is a two-winding transformer as shown in Fig. 15. These ballasts are heavily insulated to insure satisfactory operation on series circuits up to 10,500 volts rating.

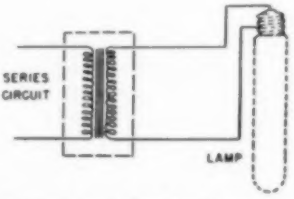


Figure 15. Mercury vapor lamp ballast for use on a series circuit.

Since the inherent regulator reactance limits current in the circuit, the individual lamp ballast does not have to be designed to limit lamp operating current, although it usually is made to have a certain amount of primary impedance with the sec-

TABLE II.—Number of Mercury Lighting Units per Circuit Calculated for Thermal-Magnetic Type Breaker.

Line Voltage	Lamps per Unit	Type of Ballast	Breaker Rating: 15	20	25	35	50
			Correction Factor (70%) for Continuous Operation of Panel Breaker*				
			10.5	14.0	17.5	24.5	35
120	1 250-Watt H5	HPF High Reactance	3	4	5	7	11
240	1 250-Watt H5	HPF High Reactance	6	9	11	15	22
120	1 400-Watt H1	HPF High Reactance (Outdoor)	1	2	3	4	6
240	1 400-Watt H1	HPF High Reactance (Outdoor)	3	4	6	8	12
120	1 400-Watt H1	HPF High Reactance (Indoor)	1	2	3	4	6
240	1 400-Watt H1	HPF High Reactance (Indoor)	3	5	6	9	12
120	1 400-Watt H1	HPF Series Capacitor	2	3	4	5	8
240	1 400-Watt H1	HPF Series Capacitor	4	6	8	10	16
120	2 400-Watt H1	HPF Lead-Lag	1	1	2	3	4
240	1 1000-Watt H12	LPF Reactor	1	1	1	2	3
120	1 1000-Watt H12	HPF High Reactance	1	1	1	2	3
240	1 1000-Watt H12	HPF High Reactance	2	2	3	4	6
460	1 1000-Watt H12	HPF High Reactance	4	5	6	9	13
240	1 3000-Watt H9	HPF High Reactance	0	0	1	1	2
460	1 3000-Watt H9	HPF High Reactance	1	1	2	3	4
240	2 3000-Watt H9	HPF Lag-Lag	0	0	0	0	1
460	2 3000-Watt H9	HPF Lag-Lag	0	0	1	1	2

*Data shown as calculated to allow sufficient capacity to prevent breaker tripping even if power is interrupted and circuit re-energized immediately.

ondary open to limit open circuit secondary voltage.

Series ballasts are available for the more popular lamps to operate from either 6.6, 7.5 or 20-ampere series circuits and can be operated on all types of moving coil constant current transformers.

Regulator Capacity

The voltage required to start a mercury vapor lamp is higher than its operating voltage. On a series circuit the available voltage of the regulator is divided among the ballasts in the secondary circuit of the regulator. Therefore, it is necessary to provide sufficient regulator capacity to provide the proper starting voltage. Since mercury vapor lamps require a higher starting voltage at low ambient temperatures, more regulator capacity per lamp is needed for low temperature operation.

The voltage across the primary of a ballast with a failed lamp will increase due to the high impedance, measured on the primary of the ballast under these conditions. To prevent destructive voltages across the lamp, socket and wiring upon the failure of lamp, the series ballast is usually designed with an air-gap in the core, which limits the secondary open circuit voltage to a safe value. Because of this air-gap, the primary power factor of the ballast is less than unity.

Since the wattage load that can be carried by a regulator decreases rapidly as the power factor of the load decreases and since the regulator must supply sufficient voltage for starting the lamps, it is necessary to provide regulator capacity for each lamp on the circuit in line with the values in Table III. As mentioned before, the capacity required is higher at low temperature. Values are shown for the principal types of lamps used on series circuits.

TABLE III.—Required Regulator Capacity per Lamp.

Starting Temperature	C-H5	B-H1 & J-H1	A-H1 & B-H1
+20°F or higher	575 W	800 W	800 W
0°F	600 W	900 W	850 W
−30°F	650 W	1000 W	900 W

Attempts have been made to avoid the necessity of providing such high regulator capacity by inserting into the circuit a relay to short out a part of the circuit until the first energized section begins to operate normally after which the balance of the lamps on the circuit is energized. While such a system will work satisfactorily, the capital investment is usually higher than that for the additional regulator capacity.

Fig. 16 illustrates a typical series street lighting circuit for a mercury vapor lamp load showing the relationship of the usual control devices.

Power Factor Correction

With mercury vapor lamp load, the secondary watts load on a properly loaded regulator is considerably less than with an incandescent lamp load. If a regulator of the normal power factor type is

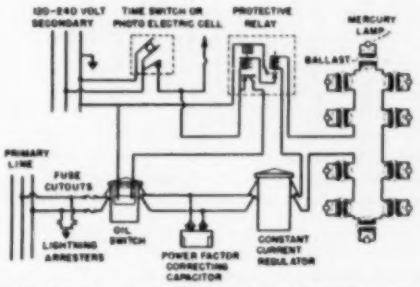


Figure 16. Series street lighting circuit for mercury lamps with typical control equipment.

used, the result will be a load with poor power factor. If power factor correction is desired, it should be obtained by using a capacitor on the primary side of the constant current transformer, either self-contained, as in the high power factor type of regulator, or separately mounted.

The normal and high power factor type regulators may be compared in Fig. 17.

Combination Mercury Vapor and Incandescent Operation

Where both incandescent lamps and mercury lamps will be used on the same series circuit, the curves shown in Figs. 18, 19 and 20 should be used to calculate the number of lamps that can be used per kw of regulator capacity.

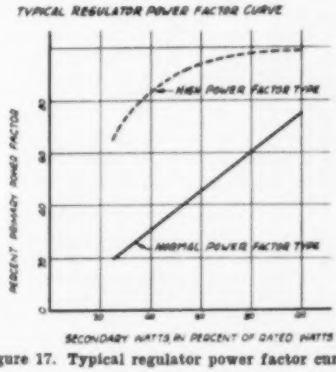

TYPICAL REGULATOR POWER FACTOR CURVE
HIGH POWER FACTOR TYPE
NORMAL POWER FACTOR TYPE
PERCENT PRIMARY POWER FACTOR
SECONDARY WATTS IN PERCENT OF RATED WATTS

Figure 17. Typical regulator power factor curve.

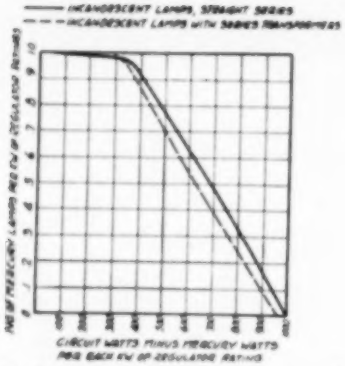

INCANDESCENT LAMPS, STRAIGHT SERIES
INCANDESCENT LAMPS WITH SERIES TRANSFORMERS
NO. OF MERCURY LAMPS PER KW OF REGULATOR RATING
CIRCUIT WATTS MINUS MERCURY WATTS PER EACH KW OF REGULATOR RATING

Figure 18. Loading curve for 50% reactance moving coil regulators. Mixed E-H1 or J-H1 lamps with series ballast and filament lamps with and without series transformers.

It should be noted that incandescent lamps may be added to a predominantly mercury lamp circuit with only a small increase in regulator capacity.

These curves contain a reasonable allowance for low line voltage and for series mercury ballasts which are open circuited. It is assumed that the insulating current transformers used with the incandescent lamps are protected against open circuit operation with cutouts. No allowance is made for a circuit having a high reactance such as would be occasioned by the use of magnetic cable sheaths. These curves are suitable for use at temperatures down to −30°F.

"Circuit Watts Minus Mercury Watts" includes the following:

1. All cable loss in the entire series circuit.
2. All transformer loss except that of the mercury ballast, (The curve for incandescent lamps with transformers allows for reactive volt-ampere load of individual transformers).
3. All lamp wattage except that of the mercury lamps.

"Mercury Watts" includes the mercury lamp wattage and mercury lamp ballast wattage loss. The quantities on the curves are to be multiplied by the regulator rating in kw.

These curves are for moving coil regulators with 50 per cent reactance. Similar curves can be developed for the nonautomatic station type regulators with 40 per cent reactance. However, most mercury lamps are used with pole type regulators which have 50 per cent reactance.

The usual monocyclic square type of static regulator does not give a sinusoidal current wave if

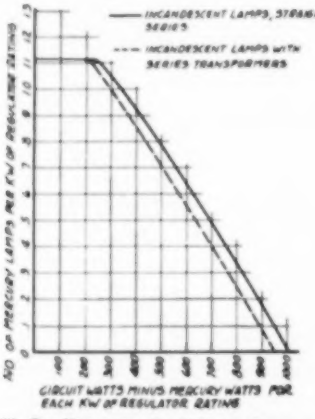

INCANDESCENT LAMPS, STRAIGHT SERIES
INCANDESCENT LAMPS WITH SERIES TRANSFORMERS
NO. OF MERCURY LAMPS PER KW OF REGULATOR RATING
CIRCUIT WATTS MINUS MERCURY WATTS PER EACH KW OF REGULATOR RATING

Figure 19. Loading curve for 50% reactance moving coil regulators. Mixed A-H1 mercury lamps with series ballast and filament lamps with and without series transformers.

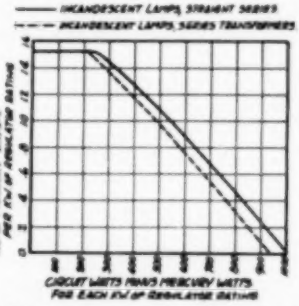

INCANDESCENT LAMPS, STRAIGHT SERIES
INCANDESCENT LAMPS, SERIES TRANSFORMERS
NO. OF MERCURY LAMPS PER KW OF REGULATOR RATING
CIRCUIT WATTS MINUS MERCURY WATTS PER EACH KW OF REGULATOR RATING

Figure 20. Loading curve for 50% reactance moving coil regulators. Mixed C-H5 mercury lamps with series ballast and filament lamps with and without series transformers.

used with vapor lamps. Consequently, monocyclic square static regulators are not recommended for mercury vapor lamp circuits.

It is suggested that seven per cent be added to the published incandescent lamp wattage in order to allow for lamp depreciation, socket drop and secondary line drop. The resulting quantity should be divided by the transformer efficiency to obtain the transformer primary wattage. The transformer efficiency will be 90 to 95 per cent, depending on the size of the transformer.

Series Operation Without Ballasts

Some few installations of mercury vapor lamps have been made with the lamps supplied directly from a series circuit. The principal advantage of this system is the lower initial cost due to elimination of the ballast.

Several disadvantages are apparent when the operation is analyzed. Special regulators must be supplied with secondary current ratings equal to

the operating current of the particular lamp to be used. Since starting current will be exactly equal to operating current, lamps will take longer to reach stable operating conditions than when used with ballasts and under certain conditions may never reach stable operating conditions.

High voltage sockets must be used to provide insulation for full series circuit. Film cutouts must be used to prevent socket destruction when lamps fail, since practically entire regulator voltage will be across failed lamp. A time delay lockout oil switch must be used to prevent puncturing of all the cutouts by the high open circuit voltage, if a power interruption occurs and service is restored before lamps have cooled sufficiently to restart.

Group Series Transformers

On series street lighting incandescent lamp circuits, a transformer known as a group series transformer is often used to supply current to an isolated group of lamps such as on an alley-way or a dead-end street. Low voltage cable can be used on the small loop of lamps supplied by the secondary of the group series transformer since this transformer insulates the loop from the main series circuit. A film cutout is placed across the secondary of the group series transformer to prevent excessive voltage on the secondary in case of an open circuit on the small loop due to broken poles, cable breakage, etc.

The group series transformer secondary winding is insulated to withstand normal operating voltage only since it is always protected by a film cutout against open circuit operation. Consequently, it is not suitable for use with mercury lamps since the high open circuit secondary voltage needed to start the lamps or encountered after a power interruption might puncture the protective film cutout incorporated in the transformer.

Group series transformer can be designed suitable for use with mercury lamps by providing insulating capacity capable of withstanding open circuit operation, but the need for such a unit has not been enough to justify its development.

Conclusion

The application of mercury vapor lamps suggests an engineering analysis of the particular lamp and ballast circuit under consideration before final selection is made. It is hoped that this discussion, pointing out some of the characteristics of particular lamps and ballasts, will be helpful to the application engineer in planning mercury vapor lighting installations.

The development of mercury vapor lamps and related equipment is accelerated by its enthusiastic acceptance as a preferred light source where high levels of illumination are required at minimum costs. Under such accelerated development, any attempt to summarize or fix characteristics may be proven obsolete with the next release of a new lamp or ballast. However, it is felt that the data herein are representative of lamps and ballasts available at this time and that by their use we will permit lighting application engineers to design more practical overall installations.

DISCUSSION

E. B. Noel*: The paper by Messrs. Burns, Freeman and Rowten is a welcome addition to the literature on mercury vapor lamps. By calling attention to significant lamp operating characteristics they will help application engineers to select the most suitable ballast and circuit arrangements for various situations.

In different parts of their paper they have touched on two factors that affect warm-up on lead circuits at cold temperatures. These are low lamp starting currents, and the change in capacitance of the capacitor which further may lower the current. It should be emphasized that the low initial lamp current is the main factor in slow warm-up or failure to warm up. Immediately after striking the lamp will have practically the same low value of voltage over quite a wide current range. The power input then is directly proportional to current, and if the current is low the wattage may be insufficient to supply the increased thermal losses at the low ambient temperature.

The rapidity of warm-up depends on many lamp design factors. While it is true that the more compact and highly loaded quarts-arc-tube lamps have short warm-up times, it should be pointed out that the long 3kw AH-9 lamp likewise warms up quickly.

The current wave form is of importance in discharge lamp operation. In extreme cases bad wave form on the supply lines has been known to cause actual ballast failure. Short lamp life will be had if the lamp current wave form is peaked as a result of supply conditions or a poor design of ballast.

The authors rightly call attention to the marked increase in starting voltage as ambient temperature decreases. At any one temperature the starting voltage varies widely from lamp to lamp and from start to start. Because of this the curve showing the relation of starting volts to ambient temperature is difficult to determine and is not as definite as other lamp electrical characteristics. Also the starting volts change with age as well as temperature. If 100 per cent of the lamps must start instantly under the most unfavorable conditions, an uneconomically high starting voltage must be provided. Our measurements on a wide variety of types and makes of lamps has shown the starting volts-temperature curve to be not a straight line but a curve concave upwards. For the lamps mentioned in Fig. 2 our data show a safe average figure to be a little higher at −20F and at +75F.

A new 1000-watt industrial lamp not discussed in the paper is the AH-15. It differs from the AH-12 in that it is designed to operate with twice the open circuit voltage, twice the arc voltage, and half the current. This means half

*Lamp Development Laboratory, General Electric Co., Nela Park, Cleveland, Ohio.

the electrode losses, and reliable cold weather starting below zero. Also when operating off of 440-472 volt industrial lines usually present where these lamps are suitable, the simple reactor ballast circuit of Fig. 5 results in a lower cost installation.

C. H. BURNS and G. A. FREEMAN*: The comments submitted by Mr. Noel are quite pertinent and bring out several of the points which could not be covered in the paper because of space limitations.

Mr. Noel's comment on factors affecting warm up on lead circuits at cold temperatures emphasizes the fact that the lead circuit must be designed with caution.

The wave shape, both of the supply and of the lamp current, are very important as pointed out by Mr. Noel. A bad wave form on the supply line, if high in third harmonic content, may cause ballast failure because of the high current through the capacitor, in the case of high power factor units. The lamp current wave form is primarily a function of the design of ballast and will be poor if the ballast is poorly designed or too little material used in its design.

Mr. Noel comments that his measurements show the curve of starting volts-temperature to be a curve concave upward. The curve shown in Fig. 2 is based on tests made on a number of lamps covering a wide range of lamp conditions. Lamps were included which were random selected from various production periods extending over many months. In addition some of the lamps were new while others had as much as 5000 hours life. The curve indicates only the most unsatisfactory conditions expected. It is true that the average values for tests would give a curve that appears slightly concave. We feel this curve is conservative and a number of years' experience with these lamps in the field has shown it to be on the safe side.

At the time this paper was written the AH-15 lamp was relatively new and we knew of no installation or field experience on the lamp; consequently it was not discussed in the paper. It is true that this lamp can be operated from a 440-480 volt industrial system with a simple reactor type ballast. Some users, however, object to a system which has 440 volts at the lamp socket in the case of a failed lamp.

*Authors.

A New Slant for Low Brightness Installation

Lighting specifications for drafting rooms call for high levels, low brightness, no glare, and no shadows. Luminous-indirect or totally indirect luminaires might do the job. But what to do when the ceilings are low?

In the drafting room of the Sheffield Corporation Engineering Department, Dayton, Ohio, the problem was met with luminaires mounted only seven feet above the floor, at a 45-degree angle diagonally across the room, in concontinuous rows. The two-lamp louvered units use 40-watt T-17, 60-inch low brightness lamps. Rows are on four-foot centers.

The illumination level obtained with this design is 85 footcandles on the drafting tables. Comfort, with no glare and virtually no shadows, is a definite factor.

This job was engineered by Don Febiger of the Dayton Power and Light Company, and J. R. Martin of Martin Electric Company, Dayton, Ohio.

Photo courtesy Edwin F. Guth Co., St. Louis, Mo.

Low Pressure Mercury Discharges

By GEORGE MEISTER
THOMAS H. HEINE

IN a previously published paper[1] on Low Pressure Mercury Discharges the gas mixtures krypton-argon and krypton-neon were considered as well as the pure gases krypton, argon, and neon. It was shown that 50 per cent krypton - 50 per cent argon and 75 per cent krypton - 25 per cent neon mixtures had a maximum ultraviolet and fluorescent efficiency at approximately 2 mm gas pressure where the voltage curve goes through a minimum. These data are now extended to include the inert gas xenon and krypton-xenon mixtures in the presence of mercury to see if there are any anomalies.

A search of the literature revealed that practically no data for xenon discharges in the presence of low pressure mercury vapor were published, but there are data on xenon itself which has been used extensively in recent years as a discharge source for high intensity illumination mainly at high pressures. Although xenon was available in Europe in the 1920s it first became commercially available in the United States about 1940 when it had impurities such as krypton to the extent of about 5 per cent. Present day xenon has less than 1 per cent krypton.

The following data contain further information on gas mixtures with xenon as one component and are compared with the previously published data.

Experimental

The apparatus used was the same as described in detail in the published paper.[1] In general the discharge tube consisted of an assembly of a water-jacketed lamp in which the lamp and water-jacket had a section of Vycor glass tubing and a lamp section coated with phosphor. This arrangement was necessary to obtain all the data required at the desired temperature. All the other equipment such as voltage stabilizers, filament transformers, discharge transformers, footcandle meters and ultraviolet meters were included in the assembly. Thus the electrical characteristics, the visible light output of the discharge, the ultraviolet output of the discharge and the fluorescent output of the phosphor were obtained under controlled conditions.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 27-30, 1951, Washington, D. C. Authors: Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.

Before and after investigating each gas or gas mixture the lamp was always seasoned and zero gas pressure data taken. The inert gases studied were krypton and xenon and mixtures of these cases at various pressures. All gas mixtures were diffused at least 16 hours. The following mixtures were used:

Krypton	Xenon
100 per cent	0 per cent
75	25
50	50
25	75
0	100

All data illustrated in the accompanying composition curves are for a constant lamp current of 500 milliamperes and for a constant temperature of 45 degrees C for different pressure parameters ranging from 1 to 5 mm. Krypton at 2 mm gas pressure is taken as the 100 per cent reference point.

Voltage Characteristics

The voltage composition curves at constant current and temperature for krypton-xenon mixtures (Fig. 1) show that the lowest voltage is obtained with 2 mm gas pressure throughout the entire range of composition from 100 per cent krypton to 100 per cent xenon. These curves, therefore, gen-

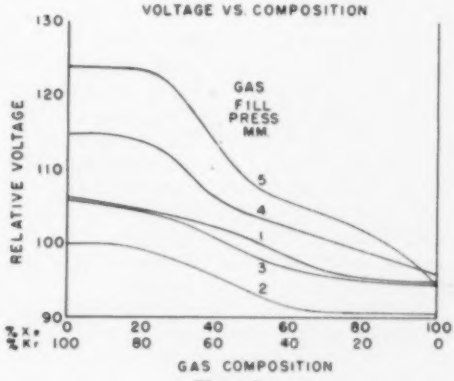


Figure 1.

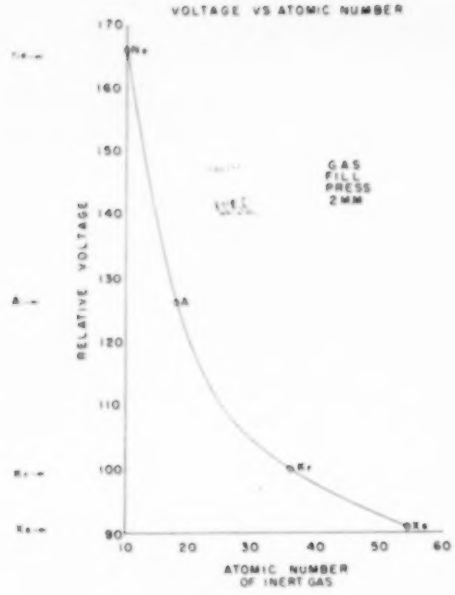


Figure 2.

erally agree with previous data[1] obtained with the krypton-argon and krypton-neon mixtures. It will be recalled, however, that in the neon-rich krypton-neon mixtures the lowest voltage was obtained with 1 mm gas pressure. The reason for this difference is that with these inert gases there is a pronounced voltage minimum at about 2 mm with krypton and xenon, but for the lower atomic number gases, which have higher ionization potentials, this voltage minimum vanishes and instead a plateau develops, especially with neon at about 2 mm gas pressure with a subsequent decrease in voltage below this pressure.

The voltage-composition curves, furthermore, are vastly different from those of the krypton-argon and krypton-neon series. When the xenon concentration is increased, they do not proceed in any regular progressive manner but show a sharp inflection at about 20 per cent xenon especially with 2, 4 and 5 mm gas pressure. Up to this xenon concentration, the voltage at each pressure is practically constant. While this inflection is not pronounced with 1 and 3 mm gas pressure, it is most pronounced with 5 mm gas pressure.

The voltage for pure xenon is practically independent of the gas pressure for 1, 3, 4 and 5 mm and amounts to approximately 95 per cent of the voltage of pure krypton at 2 mm, while for 2 mm, gas pressure it is approximately 90.5 per cent. Also, the voltages for 1 and 3 mm gas pressures are approximately the same throughout the krypton-xenon series at each pressure and vary only from about 95 per cent at pure xenon to about 105.5 per cent at pure krypton.

TABLE I.

Gas	Atomic Number	Per Cent Voltage	Ionization Potential	%
Neon	10	166	21.5	155
Argon	18	126	15.7	133
Krypton	36	100	13.9	100
Xenon	54	91	12.1	87

In the earlier paper[1] the statement was made that the voltage in these low pressure mercury discharges containing inert-gases varies directly with the ionization potential of the gas. This relation is shown by plotting the voltage against the atomic number of the gas which is correlated to the ionization potential (Fig. 2). This correlation is further shown when the relative percentage voltage values and ionization potential values are tabulated with krypton as the reference point (Table I).

Arc Characteristics

The arc efficiency-composition curves of the discharge at constant current and constant temperature (Fig. 3) show that at all pressures from 1 to 5 mm the addition of as much as 50 per cent xenon to

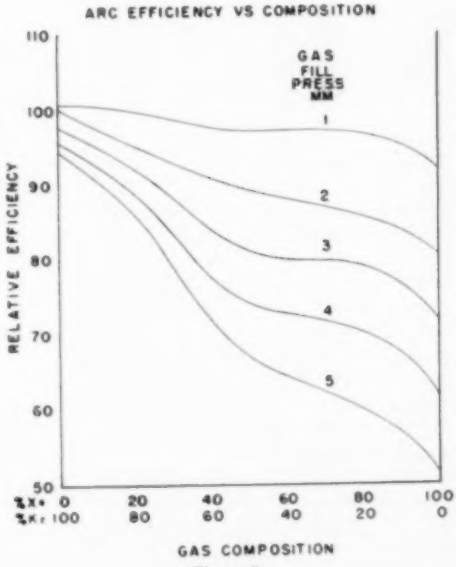


Figure 3.

TABLE II.—Maximum Arc Efficiency.

Composition		Pressure	Efficiency
Kr	Xe	mm of Hg	%
100	0	1.0	100.6
75	25	0.9	99.4
50	50	0.5	100.1
25	75	0.4	102.1
0	100	0.2	98.8

krypton causes an almost linear reduction in the visible efficiency. However, at 1 mm gas pressure, between 50 per cent xenon and 75 per cent xenon, a definite plateau develops to interrupt the smooth drop. This plateau generally becomes less pronounced as the gas pressure increases from 1 to 5 mm.

It is interesting to note that the arc visible output efficiencies for pure xenon show approximately the same large decrease as later observed in the ultraviolet and fluorescent-composition curves (Fig. 4 and Fig. 5). On the other hand, pure krypton at all pressures from 1 to 5 mm maintains a high efficiency showing a drop of only 6 per cent over that pressure range. These curves, showing pressures down to only 1 mm, compare with the curves previously published on the krypton-argon series which also showed the highest efficiency at 1 mm pressure. However, at pressures below 1 mm, not shown on the curve, the efficiencies of the pure xenon and krypton-xenon mixtures reach higher values, which are of the same order of magnitude as the pure krypton maximum. The following table presents the maximum visible output efficiencies and the pressures at which they occur for representative mixtures with krypton at 2 mm taken as the reference point (Table II).

It is noted that the maximum occurs at 1 mm gas pressure for pure krypton and then shifts gradually down to 0.2 mm gas pressure for pure xenon. This is in contrast to the characteristics previously published on krypton-neon mixtures which showed that the gas pressure for maximum efficiency gradually rose from 1 mm for pure krypton up to approximately 2 mm for pure neon. In the case of krypton-argon there was no shift in gas pressure for maximum efficiency. In connection with these maximum arc efficiencies, it should be noted that they do not occur at the pressure for minimum voltage which is the case with UV and fluorescent output efficiencies.

U.V. Characteristics

The U.V. efficiency-composition curves at constant current and constant temperature for krypton-xenon mixtures (Fig. 4) show that as the percentage of xenon is increased at 1 mm gas pressure, unlike at higher pressures, there is a gradual rise

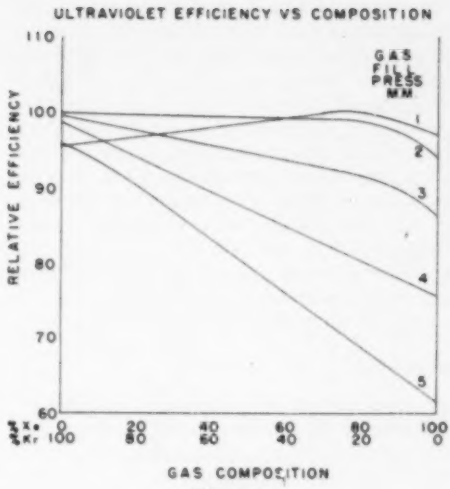


Figure 4.

in the U.V. efficiency until a slight maximum is reached at 25 per cent krypton, 75 per cent xenon. This maximum corresponds to the maximum observed in the published data for krypton-neon mixtures where the composition was 75 per cent krypton, 25 per cent neon. Higher concentration of xenon in krypton reduces the efficiency again until for pure xenon at 1 mm pressure the efficiency is about the same as that of pure krypton at 1 mm pressure.

Raising the gas pressure of pure krypton from 1 mm up to 2 mm increases the efficiency over 4 per cent up to the highest possible for pure krypton. At this constant pressure of 2 mm, increasing the percentage of xenon has practically no effect on the efficiency up to 80 per cent xenon. For mixtures containing less than 60 per cent xenon the highest U.V. efficiency is obtained at 2 mm gas pressure. This compares with the published data on the krypton-argon and krypton-neon mixtures where the highest ultraviolet efficiency was obtained at 3 mm gas pressure for pure gases and all mixtures. At xenon concentrations higher than 60 per cent, the efficiency at 2 mm gas pressure goes below that obtained for 1 mm gas pressure. After this cross-over a decline in efficiency occurs for compositions containing more than 80 per cent xenon.

All the curves for 3, 4 and 5 mm gas pressure with pure krypton show ultraviolet efficiencies higher than the efficiency at 1 mm. However, as the concentration of xenon is increased, the efficiencies cross the 1 mm curve and decrease almost linearly with composition. The efficiency decreases

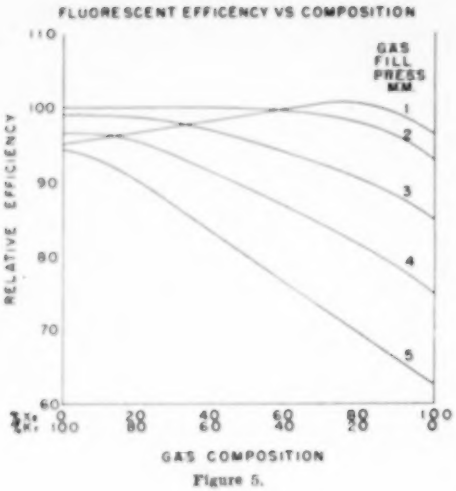


Figure 5.

more rapidly for the higher pressures so that at pure xenon there is a 35 per cent decrease in efficiency over the narrow range from 1 to 5 mm. It should be noted that for this same pressure range, the ultraviolet efficiencies for pure krypton change only 4 per cent. The corresponding range of efficiencies in pure neon and pure argon for these pressures is approximately the same as for pure krypton.

Fluorescent Characteristics

In general the fluorescent output efficiency-composition curves at constant current and temperature for krypton-xenon mixtures (Fig. 5) have the same general shape and relative output as the ultraviolet efficiency-composition curves at the corresponding gas pressures.

The highest fluorescent output efficiency is obtained at approximately 1 mm gas pressure for pure xenon and for mixtures down to about 60 per cent xenon - 40 per cent krypton. Below this composition the highest fluorescent efficiency occurs at 2 mm gas pressure, and the efficiency thus progressively decreases as the pressure increases. It is to be noted, also, that the fluorescent efficiency for pure krypton is approximately that for pure xenon at 1 mm gas pressure.

The fluorescent output efficiency for pure krypton is better than that for pure xenon at all pressures except at 1 mm gas pressure where xenon is slightly better than pure krypton. As the pressure increases from 1 to 5 mm the fluorescent output for the mixtures far exceeds that of pure xenon so that at 5 mm the fluorescent efficiency is only 65 per cent that of xenon at 1 mm. The relative decrease in fluorescent output efficiency is approximately the same as with the ultraviolet efficiency. It can be seen that there again is a correlation between ultraviolet efficiency and fluorescent output efficiency in these xenon-krypton mixtures. This observation is in agreement with the data published in the krypton-argon and krypton-neon mixtures where a similar relation was found. These curves also have a maximum at 1 mm gas pressure at approximately 75 per cent xenon - 25 per cent krypton, and therefore, coincide with the ultraviolet efficiency data. In the earlier published data for the krypton-neon mixture, a similar more pronounced peak was observed at about this composition where the mixture was 75 per cent krypton - 25 per cent neon.

Collective Data

With the addition of pure xenon to the published data on the other pure gases, krypton, argon, and neon, the characteristics for all the pure inert gases except helium have been obtained.

The relative voltage is given in Fig. 2 for 2 mm gas pressure and it can readily be seen that the lowest voltage is obtained with xenon and the highest voltage with neon. The other two gases, krypton and argon, have intermediate values but in progressive sequence with their atomic number and ionization potential (Table I).

The curves (Fig. 6) for the arc, ultraviolet and fluorescent efficiencies at 2 mm gas pressure all follow the same general course when plotted against the atomic number of the gases. It can be seen that the maximum efficiency at 2 mm gas pressure is obtained with krypton while the relative ultraviolet and fluorescent efficiencies for argon and xenon are about the same. The arc efficiency for pure xenon is relatively poorer than for any of the other gases. From these collective data it can be

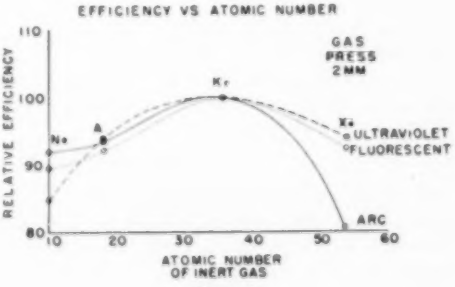


Figure 6.

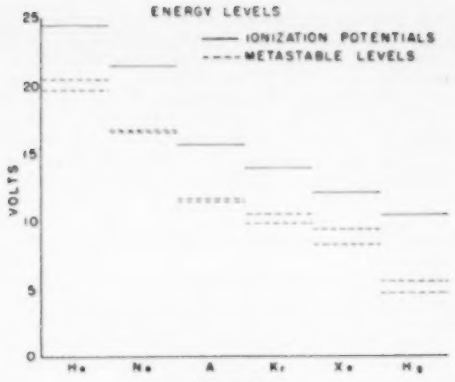


Figure 7.

concluded that for the most efficient fluorescent or ultraviolet lamps at 2 mm gas pressure krypton or krypton-rich mixtures should be used provided there are no unusual maxima produced by the inert-gas mixtures.

Discussion

In the previous publication[1] on the krypton-argon and krypton-neon gas mixtures, the ultraviolet and fluorescent efficiencies showed good correlation and there was very little spread in the relative efficiencies in the pressure range of 1 to 4 mm. The maxima in the curves for the fluorescent efficiency corresponded to the maxima in the ultraviolet efficiency curves. These efficiency curves, however, did not show any corresponding relation to the arc efficiency curves. With the present krypton-xenon gas mixtures, there not only was a correlation between the ultraviolet and fluorescent efficiency curves but there also was reasonably good correspondence with the arc efficiency curves at pressures ranging from 1 to 5 mm. It can also be seen from the curves that these ultraviolet and fluorescent efficiencies for pure xenon are comparable within a few per cent with those of pure krypton at low gas pressures of 1 to 2 mm but with pure xenon they progressively and rapidly decrease as the gas pressure is increased to 5 mm. The arc efficiencies, however, decrease rapidly from 1 to 5 mm gas pressure for pure xenon and xenon-rich mixtures. Apparently there must be some property directly associated with the xenon gas because the general shape of the efficiency curves agrees for all compositions of krypton-xenon gas mixtures. In comparing some of the properties of the inert gases that may have a direct bearing on this phenomenon, it was noted that the metastable levels[2] of xenon (Fig. 7) lie below the ionization potential of mercury. With neon and argon the metastable levels are above the ionization potential of mercury while with krypton there is one above and one below. When these gases, therefore, are excited by collision with electrons, they can influence the mercury discharge by collisions of the second kind. However, when the electrons collide with xenon atoms all the energy is lost to the xenon and there is apparently no subsequent effect on the mercury atoms thus accounting for the results obtained in these experiments. These statements at the moment are purely speculative as further data are being collected to confirm these deductions.

Conclusions

In this investigation of the krypton-xenon gas mixtures in the presence of mercury vapor at low pressure (about 9 microns corresponding to a wall temperature of 45 degrees C) a very slight maximum occurred in the ultraviolet and fluorescent output efficiency at 1 mm gas pressure for 25 per cent krypton - 75 per cent xenon. This maximum efficiency was found at a similar composition in the krypton-neon gas mixture at 2 mm gas pressure where the higher atomic number gas constituent, krypton, in the mixture was 75 per cent.

The voltage of the lamp was lowest at 2 mm gas pressure for krypton and xenon and also for the krypton-xenon mixtures. This lowest voltage was also generally observed with the krypton-argon and krypton-neon mixtures. The voltages in the krypton-xenon series have a very narrow spread going from pure krypton to pure xenon.

The arc efficiency for visible light was highest for 1 mm gas pressure for the pure gases krypton and xenon and for the krypton-xenon mixtures. The efficiencies for pure xenon and xenon-rich mixtures showed a very rapid decrease with increasing pressure, 1 to 5 mm, comparable to the ultraviolet and fluorescent efficiency curves. The highest efficiency values at 1 mm gas pressure agree in general with the data obtained with krypton-argon and krypton-neon series.

The highest ultraviolet and fluorescent efficiencies occurred at 2 mm gas pressure for all krypton-xenon mixtures containing more than 4 per cent krypton. These highest efficiencies are observed where the voltage is lowest. They, therefore, agree with those found in the krypton-argon, and krypton-neon series. The ultraviolet and fluorescent efficiencies in pure xenon and xenon-rich mixtures showed a very rapid decrease with increasing pressure, 1 to 5 mm, which was not observed in the krypton-argon or krypton-neon series.

The collective data on the characteristics of inert gases and their mixtures at 2 mm gas pressure in the presence of low pressure mercury vapor show that the highest arc, ultraviolet and fluorescent efficiencies are obtained with krypton or krypton-rich mixtures and the lowest voltage is obtained with pure xenon.

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1. Meister, G. and Heine, T. H.: Low Pressure Mercury Discharges, ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, p. 681 (November 1949).

2. Cotton, H.: "Electric Discharge Lamps" 1946, p. 123.

DISCUSSION

G. E. INMAN*: I am happy to see the interesting results obtained by Mr. Meister on the use of krypton and xenon in fluorescent lamps. This information not only checks the meager indications which we have in connection with xenon giving a lower fluorescent lamp efficiency than krypton at 2 to 3 mm pressure, but gives a rather complete story. It would appear from Fig. 5 that the efficiency of a fluorescent lamp with 1 mm of 80 per cent xenon is approximately the same as a lamp with 2 mm of krypton.

In order to find out, therefore, what might be a practical application of this work, I would like to ask if Dr. Meister might feel that in order to obtain a practical result, the cost of xenon must necessarily be less than twice that of krypton.

GEORGE MEISTER and THOMAS H. HEINE*: Thank you, Mr. Inman.

It is true that at 1 mm the 80 per cent xenon - 20 per cent krypton mixture is approximately as efficient as the fluorescent lamp with 2 mm krypton. Your statement about cost of xenon also is correct. Before xenon can be used on a large scale in commercial fluorescent lamps, the cost must be reduced to a point where it will be attractive to the lamp manufacturer. The figure of twice the cost of krypton is probably about correct, unless there is some additional advantage in the use of krypton.

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High Illumination Levels in Machine Shop

This large industrial machine ship, at the Heller Engineering and Mfg. Co., Los Angeles, Calif., has 90 to 100 footcandles of general lighting. This is provided by continuous rows of 4-lamp industrial luminaires on 8-foot centers, with mounting height of 16 feet. The lamps are 96-inch T-12 75-watt, operated on 430 ma ballasts. Supplemental lighting on machines was removed for the more shadowless general lighting.

This 12,500 sq. ft. area is engaged in the fabrication of aeroplane parts. Photo courtesy of Illuminating Engineering Unit, Business Agent's Division, Department of Water and Power, Los Angeles, Calif.

Lighting for Steel Mills
Part I: Open Hearth

Prepared by Sub-Committee on Lighting in Steel Mills of the Committee on Lighting Study Projects in Industry*

Since the manufacture of steel is an integrated process, the logical procedure in developing lighting recommendations is to start with the raw materials and follow them through the various processes to the finished products; the principal processes being blast furnaces, from which pig iron is transferred to either Bessemer converters, or open hearth or electric furnaces. The material is then subjected to various rolling operations.

Each of these processes can be considered as a separate operation. They may be located anywhere from a few hundred yards to many miles apart. The Committee, on the advice of the steel manufacturers, plans to take what it considers the most important operations first, and when all are completed to arrange them in their logical sequence.

Steel manufacture, like many other operations, is undergoing transformation to make it as automatic as possible. The industry plans eventually to scrap the older methods because of higher costs, and therefore the Committee is devoting its attention primarily to the newer mills.

Each operation covers a very large area with an extremely low occupancy. For this reason a large part of the area needs a relatively low level of illumination, in some cases just enough for safety. The seeing conditions generally are not critical. The objects viewed are very large and in many instances the brightness is so high that it would be impossible for artificial illumination to compete.

There are a few limited areas that do require critical seeing, such as final inspections, machine shops, etc.; these will be dealt with as separate reports in the future.

The general aim of the Committee is to proceed from the open hearth area to rolling operations. When this is completed there will be a return to study blast furnaces and other types of operations.

COMMITTEE ON LIGHTING IN STEEL MILLS

COMMITTEE ON LIGHTING IN STEEL MILLS

A. Paulus, *Chairman*

J. J. Booth — H. Hargest
C. M. Crysler — Lucian Kight
E. J. Enlind — H. J. Mazur
Carl Ostrom

1. Introduction

(a) The open hearth furnace refines scrap, pig iron, and other important but less bulky materials into a product suitable for rolling operations. The seeing task involves viewing very large objects handled in bulk. The furnaces are in banks and the various crews move from furnace to furnace, thus giving an almost continuous pouring operation.

(b) The seeing task in most of the areas of the open hearth operations is not critical. The charging floor is a very large area normally occupied by very few people. Most of the materials are handled by machinery and the smaller objects viewed will probably be a few small tools such as shovels and small sample ladles. The product itself is viewed through the furnace door and being molten metal has a brightness of a high order as shown in Fig. 3. During the times of charging and tapping the furnace and pouring molds from the ladle the glare or brightness is usually so high that it is impossible to offset this brightness with artificial illumination. Similarly, the pouring floor has practically no workmen except for periodic cleaning. Lighting in this area is primarily that for safety.

(c) The most critical seeing task involves the lining of "hot tops."* The material used is black which offers no contrast, and the opening is small and tilted at an angle of approximately 30 degrees above the horizontal, making it very difficult to project light into the interior. A combination of general and local lighting is therefore indicated. Another seeing task of a medium order is the repairing of the open hearth furnace. This involves rather accurate

*Approved by the I.E.S. Council, May 1951.

*Collar lined with refractory material, used on top of ingot mold.

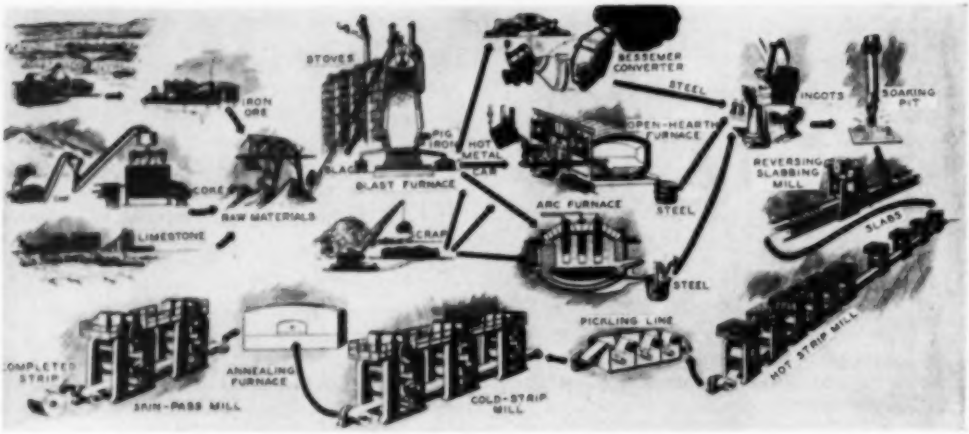


Figure 1. Flow diagram for iron and steel industry.

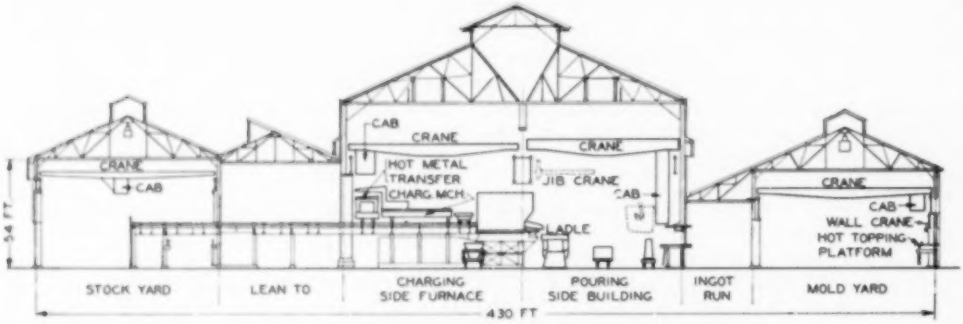


Figure 2. Section through a modern open hearth steel plant.

Figure 3. Illustrating high brightness and glare inherent in open hearth steel mills.

Figure 4A. (Top right) Day-time view of a typical open hearth charging floor.

Figure 4B. (Center right) Close up of hot metal transfer operation.

Figure 4C. (Below right) Charging machines.

brick laying operations. Since this is done at very infrequent intervals, a portable floodlight is usually used.

(d) In general, the larger portion of the areas occupied by the open hearth operations require very little little critical seeing and low levels of illumination can be used to accomplish this and also to serve as an aid to safety.

2. Description of Process

(a) The raw materials (ore, scrap, and limestone are delivered to the stock yards in standard railroad cars. The material is transferred at this point to charging boxes having a capacity of 20 to 40 cubic feet. These boxes are placed on railroad trucks and moved to the charging floor; here (see Fig. 4) the boxes are picked up by a charging machine and thrust into the furnace. A few seconds only are required to rotate the box and dump its contents, after which the charging box is removed. During the twelve-hour melting period small quantities of other materials may be added at specific times to purify or provide the desired alloy. These are fed to the furnace either by shovel or by a charging machine.

(b) At the proper time the furnace is tapped from the opposite side, the steel is run off into a huge ladle, and the lighter slag which floats on the steel is run into a smaller ladle or thimble. (See Fig. 5.) The large ladle containing the steel is picked up by an overhead crane and carried to a pouring platform (Fig. 6). Here the molten contents are poured into ingot molds mounted on cars.

(c) The ingots are generally cooled before they are moved to the stripper, shown in Fig. 7. The molds after stripping are returned for use or repairs if needed, and the ingots are delivered to the soaking pits for further processing.

Figure 5. (Above) Tapping a heat of steel from an open hearth furnace. The molten steel, heavier than slag, flows from the furnace first, nearly filling the ladle. The slag follows and overflows into the slag pot on the right.

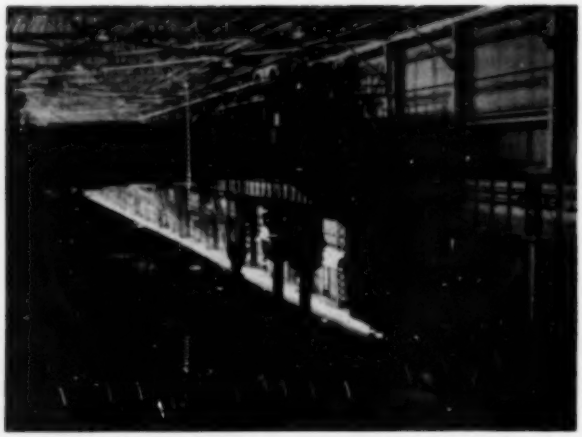


Figure 6A. (Above) General view of pouring area with ingot pouring platform in lower right corner.

Figure 6B. (Below) Ingot pouring operation.

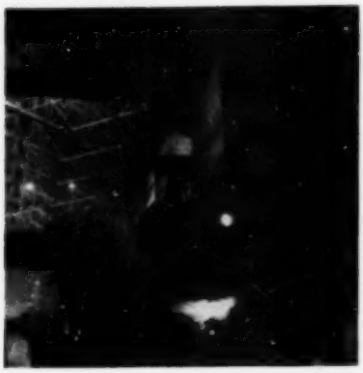


Figure 7. (Above) Ingot mold stripping. After the metal has cooled sufficiently the mold is stripped from the ingot. The ingot then goes to the rolling operation and the mold is returned for relining and repair.

Figure 8. (Right) Illustrating supplemental lighting units mounted on the underside of a crane over an open hearth charging floor.

3. Analysis of Seeing Tasks and Illumination Recommendations

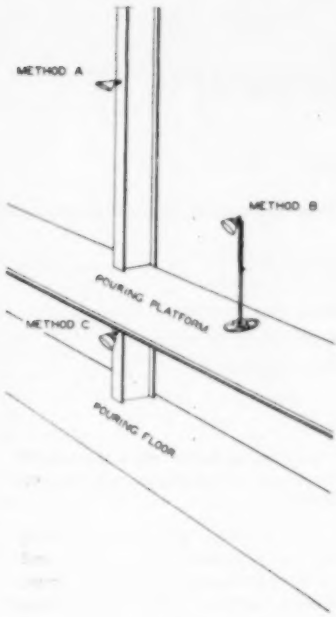
The following table indicates the area, type of operation, conditions involved and maintained footcandles for open hearth operations.

Area and Operation	Conditions	Maintained Footcandles	How Obtained*
Stock Yard			
Loading scrap metal, ore and limestone into charging boxes by overhead cranes. Stocking of these materials, also by overhead cranes.	Usually clear open space 35-50 feet high with railroad tracks running through the center. Atmosphere relatively clear except for some fumes and vapor drifting in from the pouring aisle. This area may be indoors or outdoors; in either case the area is provided with a traveling crane.	5	Indoor areas are best lighted by general overhead lighting using narrow or medium distribution for high mounting. Similar equipment should also be mounted on the underside of traveling crane. Outdoor areas are best lighted by general overhead lighting, particularly where overhead framing is available. If this is impracticable, directional lighting units having wide distribution can be mounted on the underside of crane girders.
Charging Floor			
Emptying charging boxes into furnace by machine. Adding alloy materials by shovel or charging box.	Relatively clear open space 35-50 feet high with railroad tracks and tracks for charging machines. (See Fig. 4.) Atmosphere relatively clear except for fumes and vapor drifting in from pouring aisle.	10	General overhead lighting provided by medium to concentrated distribution industrial lighting equipment. Supplemental lights should be mounted on underside of crane (Fig. 8). Localized lighting should be provided on the instrument panel which controls the furnace operation. Additional lighting should be provided over the small material storage bins. This usually can be best accomplished by mounting directional lighting equipment on the steel columns or on the underside of the crane girders.
Pouring			
Tapping open hearth furnace into ladles and emptying ladles into molds.	Concentrated area of high brightness due to molten metal. Clouds of fumes and vapor from ladles at time of tapping and pouring. (See Figs. 5 and 6.) Rough floor. Ceiling height 40-80 feet.	5 general plus 15 supplementary at slag pits and control platforms.	General overhead lighting using concentrated or medium beam distribution for high mounting. Auxiliary lighting should be provided for the slag pits. This can be done in either of two ways as shown in Fig. 9. Directional lighting equipment can be mounted permanently on the steel columns above the platform level which is part of the charging floor area. If this is not feasible, portable units mounted on a standard having either a tripod or flat platform with castors. This can be set on the platform above the slag pit area. At the ingot pouring platform supplementary lighting is necessary and can be obtained by mounting directional lighting equipment on the columns back of the platform.
Mold Yard			
Where ingot molds are cleaned, coated, sprayed, and stored.	Very dirty, with usually a high concentration of fumes from the spraying operation.	5	General overhead, plus lighting on underside of crane. Consideration should be given to suitable maintenance features such as dirt resistant design, dust-tight covers, etc.
Hot Top			
Relining and repairing the hot top section of molds.	Relatively clear except for fumes and vapor drifting in from adjacent aisles.	20	General overhead lighting of approximately 10 footcandles should be provided. Supplemental lighting at the point of hot top repairs and mold relining should be provided. Directional lighting equipment can be mounted on the overhead beams; for close inspection of the lining it is necessary to use extension cords. (See Fig. 10.)

*For typical luminaires see Appendix to be published later in reprints.

Area and Operation	Conditions	Maintained Footcandles	How Obtained*
Hot Top Storage Storage and placing hot top on molds.	Atmosphere relatively clear, requires good seeing in order to place thin steel gasket accurately between hot top and mold.	10	General overhead lighting plus lighting units under crane.
Checker Cellar Generally very little work done except for repairs. Brick work.	Fairly low ceiling area. Many supports, pipes and ducts.	5 plus supplementary	Locate overhead lights wherever possible. Provide portable local lights for repair work.
Buggy and Door Repair Repair shop for charging box, buggies, and furnace doors. Rough machine and bench work. Cutting and welding.	Typical metal fabricating shop conditions. Ceiling height usually about 15 feet.	20	General overhead lighting.
Stripping Yard Remove mold from ingot by stripping machine. (See Fig. 7.)	May be inside high bay building or outside.	10	For inside area general overhead lighting. For outdoor areas directional lighting equipment mounted under crane girders or overhead units mounted on messenger cable.
Scrap Stock Yard Active storage and cutting of scrap by torch and shears.	Usually outdoors with overhead cranes.	10	Standard industrial lighting equipment can be mounted on messenger cable strung between the crane supporting steel structure with floodlights on towers or poles erected along side of the crane runway.
Mixer Building In this area, molten metal from blast furnace is poured into a tilting vessel which acts as a reservoir. The vessel, called a mixer, has a capacity from 300 to 1500 tons.	Vapors and fumes present from the molten metal. Ceiling height is about 60 feet.	20 on pouring elevation.	Due to very large mixers and the bins containing raw material mounted above them, it is almost impossible to provide general illumination over the entire area. Lighting equipment should be located where possible and convenient. The two most important places are at the top of the mixer and at the pouring level. This should take the form of supplemental lighting either from symmetrical or directional lighting equipment.
Calcining Building Storage and crushing limestone.	Very dirty. Ceiling height varies from 60-80 feet.	10 on working platform.	General overhead lighting is not advisable due to the height of crushing machinery and bins for feeding same. Industrial lighting units should be provided at convenient locations on all working platforms or levels.
Skull Cracker Breaking up solid material which freezes on bottom or sides of ladles and breaking old ingot molds.	Usually outside with overhead crane.	5	General lighting from directional lighting equipment mounted on underside of crane girders. Lighting should also be provided under the cranes.
Cinder Dump Storage of cinders from open hearth furnace.	Outside with overhead crane.	5	General lighting from overhead or directional lighting equipment. Lighting units under crane.

*For typical luminaires see Appendix to be published later in reprints.



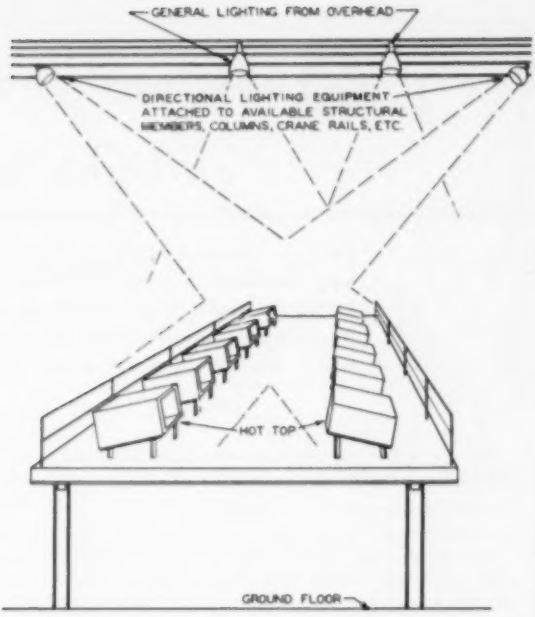

GENERAL LIGHTING FROM OVERHEAD
DIRECTIONAL LIGHTING EQUIPMENT ATTACHED TO AVAILABLE STRUCTURAL MEMBERS, COLUMNS, CRANE RAILS, ETC.
HOT TOP
GROUND FLOOR

Figure 9. (Left) Alternate lighting methods for pouring floors and slag pits.
Figure 10. (Right) Lighting for hot top repair and relining.

4. Selection of Luminaires

(a)—*Mounting Height* — Whether the open hearth is old or new, high bay areas will predominate throughout and most bays will be equipped with overhead cranes. The choice of photometric distribution will be influenced by mounting height and spacing but in general the concentrating or narrow beam type will be selected. Reflection factors of vertical surfaces are not very high when new and eventually will reach a value in the neighborhood of 5 to 10 per cent; consequently, little vertical illumination can be expected from these surfaces and where vertical illumination is definitely required (hot top repair and checker repair) it must be obtained from other than a general lighting system.

(b)—*Maintenance*—Maintenance of lighting equipment is difficult due to high mounting heights and interference with continuous operations. The resultant high depreciation should be considered in designing a lighting system. Depreciation varies with the design of the luminaire; dust-resistant features may reduce the rate appreciably. Maintenance varies widely in different plants from wiping off reflecting surfaces at time of lamp replacement to definite schedule of cleaning every 60 days. In calculating a lighting system a knowledge of maintenance schedules is necessary to determine depreciation factor.

(c)—*Light Source* — The type of power available will usually dictate the type of light source that can be used. Twenty-five cycle and direct current predominate in the older type mills. There is a trend towards 60-cycle, particularly for new mills.

Where only 25-cycle and direct current are available, filament lamps are preferable. Where 60-cycle is available it is possible to use high intensity mercury vapor lamps, either alone or in combination with filament lamps. Where mounting height is not excessive, fluorescent lamps can be applied.

Color of lighting is not very important in open hearth operations. High intensity mercury vapor lamps are satisfactory for most areas. Probably the only place where color might be a factor is on the charging floor area and there a combination of mercury and incandescent filament lamps is practicable. Machine shop or buggy and door repair departments lend themselves ideally to the use of fluorescent lighting.

SEE listing of I.E.S. Committee Personnel, beginning on page 18A. List of Section and Chapter Officers begins on page 32A.

Questions and Answers on light sources

The I.E.S. Committee on Light Sources, under the chairmanship of E. H. Raddin, has prepared this listing of answers to frequently-asked questions. Readers are invited by the Committee to submit similar questions of general interest on light sources, to be considered for publication from time to time. Questions may be sent in care of Society Headquarters.

Why do some white fluorescent lamps that look alike have different names?

White fluorescent lamps which may look alike are assigned different names when their spectral distributions are different. The way colors look under fluorescent light—color rendition—depends more upon the spectral distribution of the emitted light than it does upon the lighted appearance of the lamp itself. Thus, it is possible to have, for example, two Cool White fluorescent lamp colors that look alike, but have different color rendering properties. This is actually the case with Standard Cool White and De Luxe Cool White lamps. The Standard Cool White lamp gives reasonably good color rendition and is high in efficiency. The De Luxe Cool White lamps, in comparison, give superior color rendition with a somewhat less efficiency. The same choice is available in Warm Whites—Standard Warm White for efficiency and De Luxe Warm White for better color rendition.

What is ICI (now CIE) Illuminant C?

ICI Illuminant C is one of three internationally accepted standard sources widely used in colorimetry and agreed upon at the 1931 meeting of the International Commission on Illumination (more correctly known as the Commission Internationale de l'Eclairage or C.I.E.). The energy distributions of the three illuminants were precisely defined and are designated as follows:

1. Illuminant A—representative of gas-filled incandescent lamps and having a color temperature of 2854K.
2. Illuminant B—representative of noon sunlight and having a color temperature very close to 4850K.
3. Illuminant C—representative of average daylight from an overcast sky and having a color temperature very close to 6500K.

Illuminant A in practice is an incandescent lamp operating at a color temperature of 2854K. Illuminants B and C are obtained by modifying the light of Illuminant A by suitable filters. (National Bureau of Standards Miscellaneous publication No. M114, 1931).

Why is lumen maintenance better when a standard incandescent filament lamp is burned vertically base-up rather than base-down?

Bulb blackening is a result of gradual filament evaporation as the lamp is burned. It is a normal and inevitable result of lamp operation. In gas-filled lamps, the hot gases adjacent to the filament rise, carrying the minute particles of evaporated tungsten upward and depositing them on the inside surface of the bulb above the filament. When a lamp is burned base up, the blackening is deposited largely in the area of the base where much of the light is normally intercepted by the base, socket, and luminaire husk. If the lamp is burned base-down, the blackening collects in the bowl of the bulb where it absorbs light in addition to that intercepted by base, husk, etc.

What is the purpose of the mica disc on higher wattage general lighting service incandescent filament lamps?

Most of these lamps are operated in a base-up position wherein convection currents of the filling gas carry the heat of the filament toward the stem press, base, and socket. The disc serves to reduce the operating temperatures of these parts by providing a barrier to the hot gases.

What are the principal differences between incandescent filament lamps for general lighting service and lamps designed for rough service?

The essential differences are the diameter and length of the filament coil and the manner in which it is supported. For example, a 50-watt general lighting lamp has one support exclusive of the lead wires, and the rough service lamp of the same wattage has 16. Because of the number of supports and resultant cooling of the filament, efficiency is sacrificed and consequently the rough service type is not usually recommended for general lighting.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Action Taken at Council Meeting, New York

A meeting of the I.E.S. Council was held February 14 at the Hotel Lexington, New York City. Falling as it did the day after the meeting of the Nominations Committee, Council meeting was attended by a number of visitors in town for nominations.

Present were: S. G. Hibben, President, presiding; Past-Presidents, C. H. Goddard, Walter Sturrock; Vice-Presidents, A. H. Manwaring, E. M. Strong; General Secretary, C. C. Keller; Treasurer, R. F. Hartenstein; Directors, G. W. Beals, L. E. Tayler proxy for R. L. Biesele, Jr., D. M. Jones, R. A. Palmer, J. S. Schuchert; Regional Vice-Presidents, B. C. Cooper proxy for W. E. Folsom, P. H. Hildebrand, C. N. Laupp, F. P. Labey, M. N. Waterman proxy for C. O. Martin, R. G. Sinuer, F. C. Winkler; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Editor; and C. A. Atherton, B. J. Jensen, Joe Thomas.

Reorganization of headquarters operation, as considered by the January meeting of the Executive Committee was discussed and approved by Council. The plan approved divided the General Secretary's heavy responsibilities so that the Technical Director's operations may be the more direct responsibility of the Senior Vice-President of the Society, and those of the Publications Office the Junior Vice-President, or other member of the Council Executive Committee, as appointed.

Nominations for Officers

A report of the Board of Nominations was read by Lee E. Tayler, Chairman, indicating participation by 28 Sections in this annual Society event. In presenting his report, Mr. Tayler reiterated the importance of the Society's Sections to take part, with a representative from their own Section, in the nomination of I.E.S. national officers. Officers nominated for 1952-1953 Administration were: President, E. F. Strong; Senior Vice-President, A. H. Manwaring; Junior Vice-President, Duncan M. Jones; General Secretary, C. C. Keller; Treasurer, Kirk M. Reid. Two Directors were also nominated, namely, F. C. Winkler and J. F. Whitehead.

Handbook Completed

Bruce J. Jensen, Chairman of the Handbook Revision Committee, made a final report of this project and asked that his committee be discharged. Council took action to do so, with commendation and thanks to all concerned.

A copy of the new Handbook with a specially illuminated inscription was presented to Mr. Jensen by Ruby Redford, Editor of ILLUMINATING ENGINEERING, on behalf of the Publications Committee. The citation, in illuminated letters on the inside cover, read:

To Bruce J. Jensen
Chairman, Handbook Revision Committee
In recognition of his work in bringing to fruition the 1952 I.E.S. Lighting Handbook

The inscription was signed by the three members of the Publications Committee, E. C. Huerkamp, Chairman; H. H. Magdsick and J. M. Stedman.

A financial statement to January 31 on the Handbook project was given by Marshall Waterman, indicating that the project was carried out within the budget as reported to Council a year ago, and that the 1952 edition of 10,000 copies is expected to be completely sold this year.

New Sustaining Members

New Sustaining Members recommended by the Sustaining Membership Committee and approved by Council are:

M. B. Austin Company
1405 Shermer Avenue
Northbrook, Illinois.
Official Representative: James M. Collins

Hollywood Wholesale Electric Company
6620 Romaine Street
Hollywood 38, California.
Official Representative: Edward Meyer

The Ruby Lighting Corporation
1212 South Olive Street
Los Angeles 15, California.
Official Representative: Albert Jassim

New Members

The Board of Examiners reported the election and reinstatement of 103 Associate Members and 16 Student Members, and recommended the election by Coun-

NEW I.E.S. Lighting Handbook, specially inscribed, is presented to Bruce J. Jensen (center), Chairman of the Handbook Revision Committee. Making presentation for the Publications Committee is Ruby Redford, I.E. Editor. Looking on are S. G. Hibben, President, I.E.S.; C. L. Crouch, Technical Director; and A. D. Hinckley, Executive Secretary.

cil of 13 Members. Favorable action by Council, together with other changes in membership brings the current totals to the following:

September 30, 1951		February 14, 1952
7166	Total Membership	7207
32	Members Emeritus	33*
42	Fellows	43
1709	Members	1732
5174	Associate Members	5239
209	Student Members	260

*Includes 10 Fellows of the Society.

CONFERENCE PAPERS

Roy A. Palmer, Co-Chairman of the Papers Committee, reported on a meeting held the previous day by this Committee, at which 28 papers were considered for presentation at the Chicago National Technical Conference. He noted that sessions were shaping up on Light and Color, Sources and Circuits, Daylighting, Street Lighting, Quality, Military Applications and possibly a number of others.

Inter-Society Color Council Holds Three-Day Convention

A panel of especially interesting papers, together with exhibits and color demonstrations, were features of the three-day Convention sponsored by the Inter-Society Color Council February 7, 8, and 9 in New York City. The Convention marked the 21st Anniversary of the Council, and attracted an attendance of 375 people.

Highlights of the meeting were a number of invited papers, including several by I.E.S. members, and a concluding dinner session which featured a demonstration of color phenomena by Prof. I. A. Balinkin of the University of Cincinnati.

Papers presented included:

Introduction—by E. I. Stearns, Calco Chemical Division, American Cyanamid Company, Bound Brook, N. J.

Color and Human Efficiency—by Faber Birren, Faber Birren and Company, New York, N. Y.

Some Aspects of Color Reproduction—by Arthur C. Hardy, Massachusetts Institute of Technology, Cambridge, Mass.

Dyeing for a Living: Color in Textiles—by E. I. Stearns, Calco Chemical Division, American Cyanamid Company, Bound Brook, N. J.

C.I.E. Meeting in Stockholm (1951) — by Deane B. Judd, National Bureau of Standards, Washington, D. C.

Seeing Color Differences—by W. D. Wright, Imperial College of Science and Technology, London, England.

Color in Color Television—by Peter C. Goldmark, Columbia Broadcasting System, New York, N. Y.

The Color in Oils—by Procter Thomson, The Procter & Gamble Company, Ivorydale, Cincinnati, Ohio.

The Perception of Color — by Harry Helson, The University of Texas, Austin, Texas.

Color in Merchandising — by Kenneth C. Welch, Grand Rapids Store Equipment Co., Grand Rapids, Michigan.

Controlled Color Sequences in Time and Space — by Albert H. King, Art Center School, Los Angeles, California. (abstract films).

Right Color—Wrong Answer—by Gladys Miller, New York, N. Y.

Artists and Their Pigments — by Martin Fischer, University of Cincinnati, Cincinnati, Ohio.

The Use of Color in Color Photography—by Ralph M. Evans, Eastman Kodak Company, Rochester, N. Y.

Color Phenomena—by Isay A. Balinkin, University of Cincinnati, Cincinnati, Ohio.

Cash Prizes To Be Awarded for "My Most Interesting Lighting Job"

Final rules have been approved for the I.E.S. Contest for "My Most Interesting Lighting Installation," which is now on a national basis for the first time.

Winning entries of Section and Chapter contests will be presented at all of this year's Regional Conferences. Winners of the Regional Contests will be "finalists," competing for the final grand prize at the Chicago National Conference, as part of the Lighting Service Forum program.

These contests are a "natural" for the younger members of the Society. Cash awards plus national and local renown will accrue for many salesmen, contractors, distributors, manufacturers representatives, utility lighting specialists and others. Winners, and runners-up as well, will be considered for possible publication, with full credit, in ILLUMINATING ENGINEERING.

Prizes and rules of the local competitions may be set by the individual Sections and Chapters. For the Regional and National contests, rules have been drawn up by the Local Activities and Lighting Service Committees, copies of which have been sent to all I.E.S. groups. Regional Co-ordinator is Paul H. Hildebrand, Pennsylvania Power & Light Co., Allentown, Pa. National Contest Co-ordinator is Lee E. Tayler, Detroit Edison Co., Detroit, Michigan. Detailed copies of the rules and any further information with regard to the Contests, may be obtained from these men.

In addition to the prizes awarded by the Sections and Chapters, Regional Conference contests will award a first prize of $25.00, second prize of 15.00 plus honorable mention.

At the National Conference, the finalists will compete for:

First Prize	$100.00
Second Prize	50.00
Third Prize	25.00
Fourth Prize	15.00

Of even more importance than the money, however, is the opportunity for recognition in the presentation of one's work before a National Conference of I.E.S. and a by-lined article in ILLUMINATING ENGINEERING.

All members are urged to apply to their Section or Chapter Chairman for information on Contest Rules. Names and addresses of Section and Chapter officers are given in the back pages of this issue.

Albuquerque I.E.S. Group Considering Chapter There

An active group of I.E.S. members in Aubuquerque, New Mexico is apparently growing to Chapter size. With the blessing of their parent section, Rocky Mountain, they have elected provisional officers and have already held two well-attended meetings. The group is under the temporary direction of F. A. Dunn. From the enthusiasm and growth to date, petition for a Charter seems indicated within the next year.

Advanced Lighting Course Sponsored by Pittsburgh Section

An especially high-caliber "faculty" is a feature of the Advanced Course in Lighting now under way in Pittsburgh. Sessions for the course are scheduled weekly March 3 through April 7, from 7:00 to 9:00 p.m. Co-sponsors of the course are the Pittsburgh Section of I.E.S. and the Electric League of Western Pennsylvania.

Subjects presented and lecturers featured are:

March 3, 1952—Revised Coefficients of Utilization—What They Mean.
Leader—J. R. Jones, Westinghouse Lamp Division, Bloomfield, N. J.

March 10, 1952—Visibility Meter and Its Use and Value—Classroom Practice.
Leader—Cory Cryder, General Electric Lamp Department, Pittsburgh, Pa.

March 17, 1952 — "Illumineering" for an Optimum Luminous Environment.
Leader—H. L. Logan, Vice-President, in Charge of Research, Holophane Company, New York, N. Y.

March 24, 1952—Operation of Electric Discharge Lamps Under Adverse Weather Conditions.
Leader — Al Paulus, Westinghouse Lamp Division, Pittsburgh, Pa.

March 31, 1952—Comparison of School Lighting Systems.
Leader—Lucian Kight, Duquesne Light Co., Pittsburgh, Pa.

April 7, 1952 — Infrared, Theory, Sources—Spectral Analysis, Applications.
Leader — Ira J. Barber, Vice-President, Fostoria Pressed Steel Company, Fostoria, Ohio.

Toronto Section Holds Young Members Competition

A meeting designed specifically for their younger members was programmed recently by the Toronto Section of I.E.S. In addition to bringing young members into closer participation of Section affairs, latent talent had a chance to show itself.

Pattern for the meeting was a competition amongst younger members on preparation and presentation of a technical paper, presentation limited to 12 minutes. Papers had to be on some phase of illuminating engineering. Separate prizes of $10.00 each were awarded for Technical Preparation, and Presentation. Eight members participated, all under 35 years of age.

Judges for quality of delivery were F. Haeking, Chairman of the Public Speaking Association, University of Toronto, and F. Tucker, past-chairman of the same organization.

The prize for Technical Preparation was awarded to L. V. Mills for his paper on "Color and Vision." Presentation prize was won by Jack Mullock for his paper on "School Lighting." Suitable "Oscars" were given to the six other contestants for their excellent efforts.

Participating in the Young Members Contest were, in addition to the two winners: D. F. Knudsen, Margaret Lidstone, Gordon Nako, Keith Ormrod, John MacDonald and Bud McClennan.

Some 90 people attended the meeting, in spite of a transit strike in Toronto. The enthusiasm shown has encouraged the Section to consider making similar meetings an annual event.

School Lighting Clinic Success in Chicago

A School Lighting Clinic of rather unique format, was conducted January 30 through February 1, by the Chicago Section of I.E.S. and the Chicago Lighting Institute.

With meetings held in the Institute Auditorium, the program was repeated on each of three days, with discussion slanted to the interests of three separate groups of registrants. The first day's program was held for School Administrators, Architects and Engineers. On the second day, registrants were School Administrators, Eye and Health Specialists. The third day's program was given before Electrical Contractors, Distributors and representatives from the Lighting Industry.

Response to this Clinic was most gratifying to the sponsors. Some 309 people attended from six states, one as far away

LIGHTING CALENDAR

Society Events

March 13-14, 1952—South Pacific Coast Regional Conference, Hotel Sir Francis Drake, San Francisco, Calif.

March 20-21, 1952—Pacific Northwest Regional Conference, Hotel Empress, Victoria, B. C.

March 31, 1952—Meeting of I.E.S. National Council, Edgewater Beach Hotel, Chicago, Ill.

April 6-8, 1952—Southwestern Regional Conference, Hotel Tulsa, Tulsa, Okla.

April 20-22, 1952—Southern Regional Conference, Hermitage Hotel, Nashville, Tenn.

April 30 - May 2, 1952 — Canadian Regional Conference, Hotel General Brock, Niagara Falls.

May 5-6, 1952—Great Lakes Regional Conference, Statler Hotel, Cleveland, Ohio.

May 8, 1952—Meeting of I.E.S. Council Executive Committee.

May 21-23, 1952—East Central Regional Conference, Webster Hall Hotel, Pittsburgh, Pa.

June 18, 1952 — Meeting of I.E.S. Council, Hotel Preston, Swampscott, Mass.

June 19-20, 1952 — Northeastern Regional Conference, Hotel Preston, Swampscott, Mass.

July 10, 1952 — Meeting of I.E.S. Council Executive Committee.

September 8-13, 1952 — Illuminating Engineering Society, National Technical Conference, Edgewater Beach Hotel, Chicago, Ill.

Industry Events

March 22 - April 6, 1952—Chicago International Trade Fair, Navy Pier, Chicago, Ill.

March 24-26, 1952 — American Society Mechanical Engineers, Spring Meeting, Seattle, Wash.

March 26-28, 1952 — American Power Conference, Hotel Sherman, Chicago, Ill.

April 1-3, 1952 — Edison Electric Institute, Sales Conference, Chicago, Ill.

April 1-4, 1952 — Greater New York Safety Council, 22nd Annual Safety Convention & Exposition, Hotel Statler, New York City.

April 16-18, 1952—Electrical Manufacturers Representatives Club of New England, 11th Annual Electrical Trade Show, Exhibition Hall, Mechanics Building, Boston, Mass.

April 28-30, 1952—Canadian Electrical Distributors Association, General Brock Hotel, Niagara Falls, Ont.

April 28 - May 3, 1952 — Chamber of Commerce, Annual Meeting, Washington, D. C.

May 4-8, 1952—The Electrochemical Society, Inc., National Convention, Benjamin Franklin Hotel, Philadelphia, Pa.

May 5-7, 1952 — Engineering Institute of Canada, 1952 Annual Meeting, Hotel Vancouver, Vancouver, B. C.

May 5-9, 1952 — 33rd Annual National Restaurant Association, Convention & Exposition, Navy Pier, Chicago, Ill.

May 6-9, 1952 — Fourth International Lighting Exposition & Conference, Cleveland Municipal Auditorium, Cleveland, Ohio.

May 8-9, 1952 — Public Utilities Advertising Association, Annual Convention, Hotel Radison, Minneapolis, Minn.

May 12-13, 1952 — Electrical Contractors Association of Ontario, Annual General Meeting, General Brock Hotel, Niagara Falls, Ont.

June 2-5, 1952 — Edison Electric Institute, 20th Annual Convention, Cleveland, Ohio.

June 6-21, 1952 — International Organization for Standardization (ISO), General Assembly, Council and a Number of Technical Committees, Columbia University, New York, N. Y.

Week of June 9, 1952 — 44th Annual Convention, National Association of Electrical Distributors, Atlantic City, N. J.

June 9-13, 1952 — Third Annual Conference on Industrial Research, Columbia University, New York, N. Y.

June 23-27, 1952 — Summer General Meeting, American Institute of Electrical Engineers, Hotel Nicollet, Minneapolis, Minn.

Week of June 23, 1952—American Society for Testing Materials, 50th Anniversary Meeting, Hotels Statler and New Yorker, New York, N. Y.

June 30 - July 2, 1952—Canadian Electrical Association, Annual Convention, Banff Springs Hotel, Banff, Alta.

August 19-22, 1952 — Pacific General Meeting, American Institute of Electrical Engineers, Phoenix, Ariz.

September 8-10, 1952—American Standards Association's Third National Standardization Conference, Museum of Science and Industry, Chicago, Ill.

September 8-11, 1952 — Institute of Traffic Engineers, Annual Meeting, Hotel Sherman, Chicago, Ill.

October 1-3, 1952—Canadian Electrical Manufacturers Association, 8th Annual Meeting, General Brock Hotel, Niagara Falls, Ontario.

October 7-9, 1952 — Pacific Coast Regional Restaurant Convention and Exposition, Biltmore Hotel, Los Angeles, Calif.

October 13-17, 1952—Fall General Meeting, American Institute of Electrical Engineers, New Orleans, La.

October 20-24, 1952 — 40th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

November 10-13, 1952 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

January 19-23, 1953—Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 9-12, 1953—National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

Week of May 24, 1953—45th Annual Convention, National Association of Electrical Distributors, Stevens Hotel, Chicago, Ill.

June 29 - July 3, 1953 — Summer General Meeting, American Institute of Electrical Engineers, Atlantic City, N. J.

August 18-21, 1953—Pacific General Meeting, American Institute of Electrical Engineers, Vancouver, B. C.

September 21-26, 1953—25th Jubilee Meeting, International Association of Electrical Inspectors, Edgewater Beach Hotel, Chicago, Ill.

November 9-12, 1953 — National Electrical Manufacturers Association, Haddon Hall Hotel, Atlantic City, N. J.

as Rhode Island. A great majority of the registrants were School Administrators, with good attendance also by architects, eye specialists, and contractors.

The lighting literature distributed included a copy of the January 1952 issue of ILLUMINATING ENGINEERING, in which special emphasis was given to school lighting.

Chairmen for the three clinics were: Erie H. Church, Benjamin Electric Mfg. Co. (who also served as Conference Chairman), M. M. Cruft, Assistant Superintendant of Schools, State of Illinois, and G. K. Hardacre, Public Service Co. of Northern Illinois.

The program repeated each day featured the following lectures:

Introductory Remarks—Ralph Lusk, Commonwealth Edison Company.

Approach to Today's School Lighting—L. V. James, Illuminating Engineering Consultant.

Seeing in Today's School Room—S. K. Guth and C. J. Allen, General Electric Company, Cleveland, Ohio.

Furnishing Today's Classrooms — O. H. Breidert, Childs & Smith, Architects.

Artificial Light Sources in Today's School Systems—Professor John O. Kraehenbuehl, University of Illinois.

Wiring of Schools—Frank McShane, Commonwealth Edison Company.

Sports Lighting in Today's Schools—Merle E. Keck, Westinghouse Electric Corporation, Cleveland, Ohio.

Applied Fluorescent Systems—William Foulks, Curtis Lighting, Inc.

Structural Fluorescent Systems—B. S. Benson, Jr., Benjamin Electric Manufacturing Co.

Applied Incandescent Systems — David H. Mason, Mason and Basedow.

Forum—Question and Answer Period—Discussion Leader, Willard Allphin, Sylvania Electric Products Inc., Ipswich, Mass.

Pictorial Tour in Slides—G. C. Fowler, Public Service Co. of Northern Illinois.

Summary of Complete Program—C. L. Crouch, Technical Director, Illuminating Engineering Society.

Store Design Panel Sponsored By I.E.S. in Toledo

The Northwestern Ohio Chapter of I.E.S. (Toledo, Ohio) were sponsors of a highly successful discussion on Lighting as a Function of Store Design aimed to the interests of merchants, architects and engineers, held last month in Toledo. Kenneth C. Welch, Grand Rapids Store Equipment Co. and a member of several I.E.S. committees, was moderator. Mr. Welch later reviewed for the panel recent developments in modern store lighting with color slides. 175 persons attended this program.

Toledo experts on the panel were Fred Sage, Construction Superintendent at Lasalle's Department Store, Herman H. Feldstein, Toledo Architect, and Robert L. Schifferly of Robert L. Schifferly Display Mfg.

April 10th will be the date for another parallel meeting on Lighting as a Function of Merchandising at which Don P. Caverly of Sylvania Electric Products will be moderator. Others on the panel will be Michael Surso of Lamson Bros. Co. who will present the store executive's view, A. J. Ritter of B. R. Baker Co., the display manager's view, and Mrs. H. Creston Doner, the customer's view.

H. L. Logan To Address British I.E.S. Convention

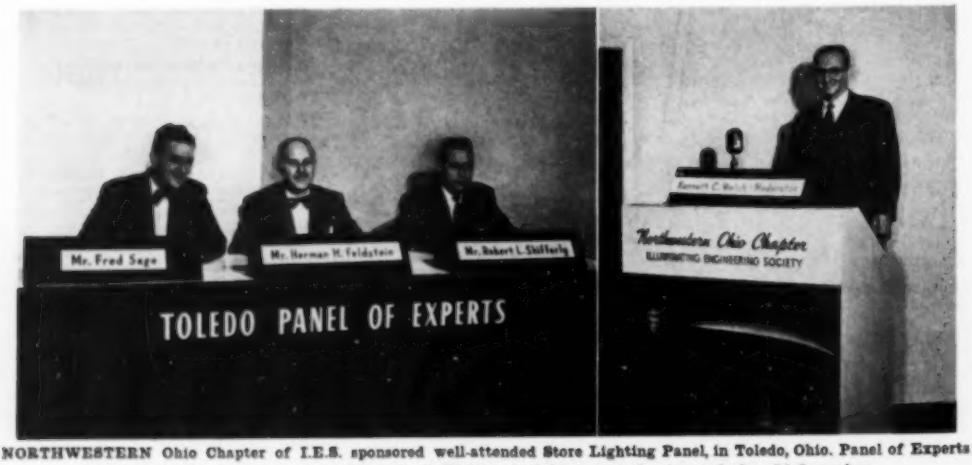
At the meeting of the British Illuminating Engineering Society, scheduled to be held in Easthorne (England) May 20-23, H. L. Logan, Director of Research for Holophane Co., New York, will address the convention as a guest speaker. Mr. Logan's address will be on "Two Frontiers of the Lighting Art," carrying on the theme of Dr. Ward Harrison's previous talk before the same group last year which was titled "Some Frontiers of the Lighting Art."

Connecticut Section Sponsors Course in Illuminating Engineering

A one semester course entitled "Radiadiation, Vision and Color" is now underway at the University of Connecticut under the direction of Prof. Domina Eberle Spencer, and sponsored by the Educational Committee of Connecticut Section. Starting February 13, the course will meet each Wednesday for the rest of the semester.

Many practical as well as theoretical applications of light and light measurement will be discussed as well as a quantitative basis for treating light and color, with a view to presenting some knowledge of vision both in the laboratory and in the office or classroom.

In general the course deals with the concepts of radiometry and photometry including problems in the infra-red. A quantitative treatment of light, vision and color based on physical principles. The unit sphere method of calculating the distribution of radiant energy from



NORTHWESTERN Ohio Chapter of I.E.S. sponsored well-attended Store Lighting Panel, in Toledo, Ohio. Panel of Experts is shown in the picture at left. Kenneth C. Welch, at right, was moderator and also chief speaker.

various sources. Interflections of radiant energy in enclosures, and applications to lighting design, and study of blackbody radiators.

It also includes the photochemical theory of vision, light and dark adaptation, vision with uniform and non-uniform surrounds, and state of adaptation of the fovea.

The color division of the course deals with physical specifications of color, trichromatic state of adaptation, color matching, the Munsell system, color harmony, and the Birkoff theory of aesthetic measure.

Further information on this course may be obtained from Edward Cole, Hartfort Electric Light Company, Hartford, Conn.

Seminar on Lighting Design Given by New York Groups

A new series of twelve advanced lectures on lighting design has been arranged by the Illumination Division of the New York Section of A.I.E.E. and the New York Section, I.E.S., and is currently being presented. Specialists in their fields have been invited to exchange ideas on the subjects below at round table discussions.

February 11—What is good lighting in 1952?
February 18—High Bay Lighting.
February 25—Television Studio Lighting.
March 3—Church Lighting.
March 10—Airport Lighting.
March 17—Mirrors, Prisms and Lenses.
March 24—Theatrical Lighting.
March 31—Lighting at the United Nations Buildings.
April 7—Lighting Aboard Ships.
April 14—Hospital Lighting.
April 21 } To be scheduled.
April 28 }

The seminar is being given in the Conference Room at the Underwriters' Laboratories, 161 Sixth Avenue, New York, N. Y. Attendance is limited to 50. Tuition is $10 to members of A.I.E.E., I.E.S., A.S.M.E., A.S.C.E., and A.I.A.; $15 to non-members. Single lectures are at $1.00 each for members and $1.50 for non-members.

Traffic Engineer Honored By City of Seattle

Seattle, Washington, said to be first in traffic safety of cities of its size in the country, recently paid tribute to its retiring traffic engineer, J. W. Arch Bollong, who did much to give the city its good safety record. In a meeting of the Seattle Safety Council, of which Mr. Bollong was one of the founders in 1934, 71 civic leaders and engineers expressed good will and the best of business to him in his new work as J. W. Arch Bollong and Associates, traffic and transport consultants.

I.E.S. Regional Conferences, 1952

South Pacific Coast	Sir Francis Drake Hotel San Francisco, Calif.	March 13-14
Pacific Northwest	Empress Hotel Victoria, B. C.	March 20-21
Southwestern	Hotel Tulsa Tulsa, Okla.	April 6-8
Southern	Hermitage Hotel Nashville, Tenn.	April 20-22
Canadian	General Brock Hotel Niagara Falls, Ont.	April 30 - May 2
Great Lakes	Statler Hotel Cleveland, Ohio	May 5-6
East Central	Webster Hall Hotel Pittsburgh, Pa.	May 21-23
Northeastern	Hotel Preston Swampscott, Mass.	June 19-20

Clinic for Industrial Safety Sponsored by Chicago Section

One of several comprehensive Clinics scheduled by the Chicago Section was held December 7 at the Chicago Lighting Institute, featuring Lighting for Industrial Production and Safety. Co-sponsor was the Chicago Association of Commerce and Industry. The meeting was attended by several hundred people from industry, as well as utility representatives and lighting engineers. The following series of discussions were presented:

Need for Increased Production and Safety in Industry, by E. E. Frederick.
Fundamental Factors of Industrial Lighting, by W. D. Richards.
Industrial Light Sources, by Carl F. Jensen.
Outdoor Lighting of Plant & Yard Areas, by James Weeks.
Lighting Production Areas, by James Chambers.
Inspection Techniques and Localized Lighting Equipment, by R. J. Diefenthaler.
Lighting Industrial Office Areas for Efficiency, by George Gilleard.
Infra Red & Ultra Violet Uses in Industries, by Harold Bunte.
Industrial Distribution Wiring Systems for Lighting, by Frank McShane.

April 4 is the scheduled date for a similar Clinic on Color, to be held at the Chicago Lighting Institute.

Montreal Section Sponsors Forum on Industrial Lighting

A one-day Forum on Industrial Lighting was held at the Queen's Hotel in Montreal, February 20, sponsored by the Montreal Section of I.E.S.

Starting with a joint luncheon of the Electrical Club of Montreal and the I.E.S. Montreal Section, the Forum continued throughout the afternoon and well into an evening session.

Forum Chairman was R. S. Tate, Canadian General Electric Co., Montreal. Subjects presented included:

Engineered Lighting, A Dynamic Force by Duncan M. Jones, Curtis Lighting of Canada, Ltd.

Lamps for Industry, by G. F. Mudgett, Canadian Westinghouse Supply Corp., Toronto.

Design and Operation of Fluorescent Ballasts, by N. A. George, Canadian General Electric Co. Ltd., Toronto.

Industrial Applications, by W. Dalrymple, Amalgamated Electric Co. Ltd., Toronto.

Colour Conditioning for Industry, by G. E. O. Fearnley, International Paints Ltd., Montreal.

Lighting of New Radio Canada Building, Dorchester St., Montreal, followed by conducted tour.

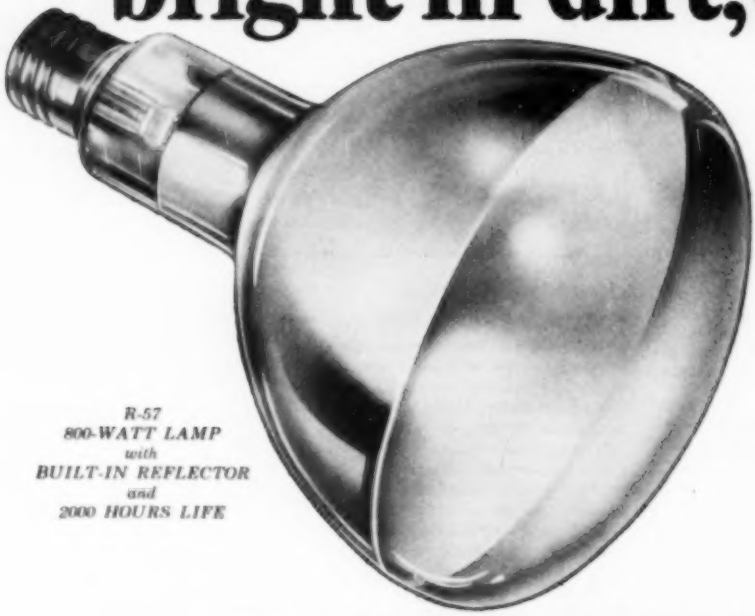
Cleveland Section 1952 Student Competition

The 1952 A.I.A.-I.E.S.-S.I.D. Student Competition, sponsored jointly by the Cleveland Section of I.E.S. together with the architects and decorators, got under way February 4, at the Cleveland Institute of Art. Ernst Payer of A.I.A. led off the discussion with "The Integration of Architecture, Design, and Lighting." Wm. Steiner and John Neidhart of I.E.S. lectured, respectively, on "Lighting—Its Language and Measurements," and "Methods of Illumination Design."

Two more lecture sessions followed on successive Mondays at the Lighting Institute at Nela Park. On February 11 the talks were by three I.E.S.ers: C. M. Cutler on "Design for Environment," C. L. Amick on "Light Sources — Types,

(Continued on page 13A)

New Westinghouse bright in dirt, dust,



R-57
800-WATT LAMP
with
BUILT-IN REFLECTOR
and
2000 HOURS LIFE

Now you can get bright light *longer* in high-bay areas, no matter how dirty, dusty or smoky the conditions. The new Westinghouse R-57 800-watt standard voltage lamp, with a special silvery reflector actually built inside the bulb itself, prevents dirt particles from reducing its highly efficient light output. Dust settles only on the sides, not on the light-emitting face, so no cleaning is needed.

In addition, the new R-57 lamp lasts 1000 hours longer than conventional lamps and directs all the light on the area where it is needed. It is available in two light distribution types: narrow or wide beam.

For full information, contact the Westinghouse Lamp Sales Office nearest you. Or simply mail the coupon below.

LAMP DIVISION • WESTINGHOUSE ELECTRIC CORPORATION • BLOOMFIELD, NEW JERSEY

YOU CAN BE SURE... IF IT'S

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lamp stays and smoke

ACTUAL EFFICIENCY STUDIES PROVE new Westinghouse R-57 800-watt lamps out-live, out-perform conventional lamps. And their special design makes them ideal, especially for high-bay lighting in foundries, mills and other industries where dust is a problem.

R-57 WESTINGHOUSE LAMPS have built-in reflector, stay bright longer with no cleaning; give more efficient light at lower cost.

AGAIN WESTINGHOUSE MAKES HISTORY! Brings you complete coverage of Presidential Campaign from conventions to election over CBS television and radio . . . Also tune in WESTINGHOUSE STUDIO ONE every week over CBS-TV.

WESTINGHOUSE LAMP DIVISION DEPT. CE
BLOOMFIELD, NEW JERSEY

I'd like to have more information about the new Westinghouse R-57 800-watt lamp.

NAME.....

COMPANY.....

ADDRESS.....

CITY.....STATE.....

NEWS FROM WESTINGHOUSE, THE FASTEST-GROWING LAMP MANUFACTURER

by Sam Hibben

DID YOU KNOW? Owls see in near-darkness (not in total darkness, which almost never exists outdoors) because of the nature of their eyes and not the size of them. Because of two shapes of nerve-ends in the back of the eyeball, we say that humans have both "rod" vision and "cone" vision. The rods take over in dim light while the cones function in brighter light and give us color perception. Owls, cats, and other night-life have mostly or entirely "rod" vision, hence see moving objects in the dimmest lights, because apparently the nerve-rods work in bunches, thus multiplying the sensitivity.

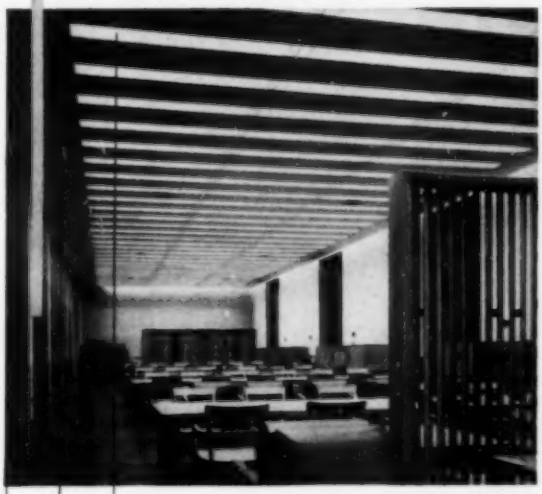
ON THE OTHER HAND—While blackout driving proved possible but unsatisfactory in war-time, the effort of auto safety experts is to approximate daylight seeing conditions as nearly as possible—at least to make roadway objects visible as far ahead as it takes to stop your car—roughly 300 feet. Headlights today are so highly scientific that a pair of small 45-watt filaments illuminate a road area at least 20 times the largest living room. Their complexity is shown by the fact that Westinghouse Sealed Beam Headlamps, for instance, have 121 individual prisms, and all of these direct separate beams of light picked up from various parts of the reflector. I guess that makes them about 60 times as complicated as bi-focals, no?

SAFETY NOTE: If you ever blow a fuse in your car on a busy highway at night, illuminate the interior of your car with a flashlight; it makes the windows visible for a long distance, warns other motorists.

More next month.

Samuel G. Hibben

BUY NOW AND SAVE! WESTINGHOUSE FLUORESCENT LAMPS STILL COST YOU LESS THAN THEY DID IN 1940, YET BURN SEVEN TIMES LONGER!



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schools
stores
public buildings

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Miller lighting systems give you the maximum benefit of *proper* lighting. Easy, accurate vision for best accomplishment. They are engineered for easy installation—for low maintenance—for long service—for finest dollar-for-dollar value. Behind them are 108 years of pioneering and progress in GOOD LIGHTING. There's no need to compromise on lighting that's "almost" right. Miller has a complete line of luminaires—Fluorescent, Incandescent, and Mercury-vapor—that cover a wide range of industrial and commercial lighting requirements—that have been proven in thousands of installations. Light with confidence the *proven* Miller way. Miller field engineers and distributors are conveniently located for nation-wide service.

Luminaire shown is the Miller deep aluminum Troffer—the ultimate in low brightness for lighting comfort. Like all Miller Troffers, units can be arranged to form ceiling patterns as desired—CEILINGS UNLIMITED®

®Reg. trade-mark U. S. Pat. Off.

Interior shown is Lamont Library, Cambridge, Mass.
ARCHITECTS, Coolidge Shepley Bulfinch and Abbott, Boston, Mass.
LIGHTING ENGINEER, Willard Thompson, Boston, Mass.
ELECTRICAL CONTRACTOR, Hixon Electric Co., Boston, Mass.

THE miller COMPANY MERIDEN, CONN.
SINCE 1844

ILLUMINATING DIVISION: Fluorescent, Incandescent, Mercury Lighting Equipment
HEATING PRODUCTS DIVISION: Domestic Oil Burners and Liquid Fuel Devices
ROLLING MILL DIVISION: Phosphor Bronze and Brass in Sheets, Strips and Rolls

(Continued from page 9A)

Colors and Operation," and R. Dorsey on "Control of Light — Characteristics of Materials."

The concluding session on February 18 featured Professor R. C. Putnam of Case (I.E.S.) on "Lighting Equipments — Types of Distribution," a panel discussion in which representatives of all three societies participated, and inspection of the home and store areas of the Lighting Institute, conducted by Kaye Leighton (I.E.S.) and Wilbur Riddle (I.E.S. and A.I.A.).

The problem, this year the remodeling of a restaurant, will be presented to the students early in March. As in the past, students from Case Institute of Technology, the Cleveland Institute of Art, and Western Reserve School of Architecture will compete. Awards will be made at the joint A.I.A.-I.E.S.-S.I.D. meeting scheduled for April 23.

High Frequency Fluorescent Lighting Discussed at A.I.E.E. Meeting

The principles of high frequency fluorescent lighting for general applications were demonstrated to the New York Section of A.I.E.E. February 6, by John H. Campbell, General Electric Co., Lamp Department. As described by Mr. Campbell, the technique involves a new lamp circuit and a newly developed method of frequency conversion whereby a small capacitor weighing only a few ounces serves as a ballast and conversion from 60 to 360 cycles is accomplished by magnetic means rather than by moving parts as in rotating or vibrating equipment.

Mr. Campbell states: "It appears that we now have the opportunity to make another great stride forward in some fields of fluorescent lighting. With the magnetic frequency converter as a power supply, we have a means for increasing the frequency in much the same way as a transformer is used to increase voltage. At the present time the overall weight of the 360 system is approximately the same as for 60 cycles but about 95 per cent of this weight can be placed in the transformer vault rather than at the lighting fixtures. The present converter requires a three-phase 60-cycle input and produces 360 cycle single phase output with a nearly square current wave shape.

"The operation of fluorescent lamps at 360 cycles offers many advantages over the conventional 60-cycle system. For example it is practical to increase lamp current thus obtaining more light output per fixture. The capacitor ballast located at each lamp weighs only a few ounces resulting in considerably lighter fixtures. The air conditioning load can be reduced because of the relatively low loss of the capacitor ballast. Radio interference is much less when fluorescent lamps are operated at higher frequencies.

"The use of the 360-cycle system in the special application at Beltsville, Md., suggests possibilities for other lighting fields such as Industrial, Office, Library and Television studios. The 360-cycle system may provide the illumination engineer with a better means of obtaining the often needed higher levels of illumination.

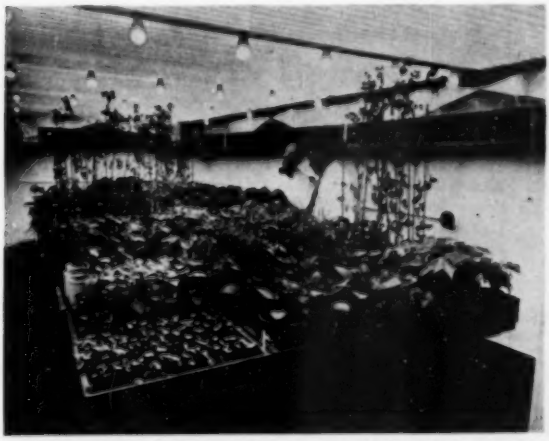
"Extended use of high frequencies for fluorescent lighting depends in part on the relative economics of the system. Comparative cost studies to determine this factor are continuing."

I.E.S. Vice-President To Attend French Conference

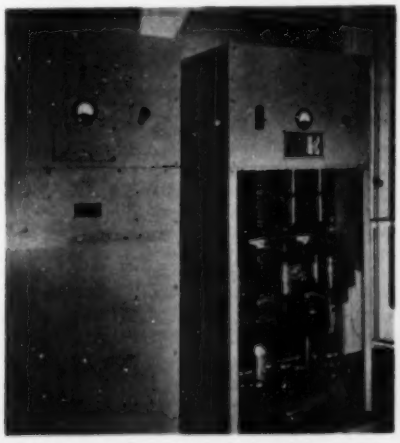
At the Convention of the French Illuminating Engineering Society scheduled April 29 through May 3 in Toulouse, France, the American I.E.S. will be officially represented by A. H. Manwaring, Vice-President. Mr. Manwaring has been appointed an authorized delegate to the conferences of the Association Francaise des Eclairagistes and will address the group on the general activities of the American I.E.S.

The three-day Conference of the French Society will include, in addition to a number of paper sessions, a Light Exhibition in Toulouse, a show-window lighting contest for local shopkeepers, some demonstrations of street lighting, and floodlighting of a number of historical monuments.

(Telecast continued on page 14A)



TYPICAL plant growth room at Beltsville, Md. 96-inch T-8 slimline lamps are spaced one inch apart. Inspecting the plants are Dr. Parker and Dr. Borthwick, physicists at the Plant Industry Station. By controlling plant growth with artificial light these men have uncovered many of nature's "energy storage" secrets and the experiments are being watched with interest by lighting engineers.



TWO 4½-kw magnetic frequency converters in use at the Plant Industry Station. This power supply converts three-phase 60-cycle to 360-cycle single phase. Each converter operates 44 96-inch T-8 slimline lamps at 500 ma. Small control knob at right will select any lamp current from 350 to 500 ma.

(Continued from page 13A)

What To Do With Your Old Handbook

The first edition (blue cover) I.E.S. Lighting Handbook is fast being replaced on thousands of shelves, by the new Second Edition (red cover) book.

Members looking for a useful home for their old Handbooks may wish to know that such books are welcomed by the United States Book Exchange, for shipment to libraries and universities in devastated Europe. If you wish to contribute to this program, send your old I.E.S. Lighting Handbook, prepaid, to:

United States Book Exchange
1816 Half St., S. W.
Washington 4, D. C.

C.L.I. Presents Annual Winter Courses

Co-sponsored jointly by the Illinois Institute of Technology and the Chicago Section, I.E.S., the Winter Quarter courses have been presented by the Chicago Lighting Institute.

"Electricity in Commercial Buildings" was given to acquaint commercial building managers, building engineers and architects with the fundamentals of alternating current wiring for light-power, modern lighting design and air conditioning for both cooling and heating. The course is divided into two ten-lesson topics. Part One is offered in the Winter Quarter; Part Two will be given in the Spring Quarter. Instructors giving this course are Frank R. McShane, E. F. McDonnell, Jr., G. Gill Fryder.

"Lighting Fundamentals," comprised of twelve lecture and six laboratory sessions, was intended for those who are new in the lighting field and those who want a brush-up in the underlying principles of illumination. Instructor for lecture sessions was Robert Ligare, for laboratory, Raymond E. Wozniak.

"Lighting Design Problems," also consisting of twelve lecture and six laboratory classes, was a practical course appealing to architects, engineers, contractors and others whose business it is to design lighting layouts and installations. R. R. Lusk was lecture instructor and W. D. Richards handled the laboratory sessions.

ABOUT PEOPLE

S. L. Drumm, vice-president in charge of sales, New Orleans Public Service Inc., has been elected Chairman of the Better Light Better Sight Bureau. Mr. Drumm succeeds **Ralph P. Wagner** of the Niagara Mohawk Power Corp., Albany, N. Y., who has been Chairman of the Bureau since 1948.

Sola Electric Company, Chicago, Ill., has announced the appointment of **Hans U. Hjermstad** as vice-president in charge of engineering. He will continue to head the engineering department and engineering laboratory.

Major organization changes among the managerial personnel of General Electric's Lamp Division at Nela Park, Cleveland, have been announced by Fred F. Harroff, vice-president and general manager of the division. **Fred J. Borch** assumes special administrative assignments, and **Carl L. Olson** is now

(Continued on page 17A)

Some Lighting Installations To See in the South

Installation at	Address	Type of Lighting
	AUGUSTA, GEORGIA	
Callum's Inc. (Department Store)	710 Broad St.	Louverall front through glass. Louverall interior area.
Elks Club	519 Greene St.	Cove lighting in Dining Room.
National Exchange Bank	1602 Walton Way	Louverall and troffers.
Georgia Railroad Bank	701 Broad St.	Coffer—40 feet long—plus supplementary lighting.
Augusta Municipal Airport		Various indoor and outdoor types.
Davison Paxon	864 Broad St.	Recessed incandescent and semi-recessed.
	LITTLE ROCK, ARKANSAS	
Pfeifers Department Store	6th & Main	Fluorescent with louverall ceiling.
War Memorial Stadium	Fair Park	Incandescent floodlighting.
Stiffts Jewelry Store	511 Main	Incandescent and fluorescent.
East Side Jr. High School	14th and Scott	Incandescent.
Lane Rexall Drug Store	423 Main	Fluorescent and incandescent.
Arkansas Power & Light Co.	123 W. 4th	Fluorescent.
Electrical Hospitality House	117 W. 4th	Cove—fluorescent and incandescent.
Bell Telephone Bldg.	5th and Izard	Fluorescent.
Federal Reserve Bank	121 W. 3rd	Fluorescent.
Arkansas Radio & Appliances Co.	307 E. Markham	Incandescent and fluorescent.
Haverty Furniture Co.	413 Main	Fluorescent.
	TULSA AND BARTLESVILLE, OKLAHOMA	
Lobby, National Bank of Tulsa	4th and Boston	Custom-built fluorescent.
Boswell's Jewelry Store	509 S. Main	Recessed incandescent with interesting cireline designs.
Vandever's Main St. Store	511 S. Main	Custom-built fluorescent.
First National Bank	5th and Boston	Many types in this new building.
Stanolind Pipe Line Bldg.	6th and Cincinnati	Various fluorescent applications in this new building which includes the University of Tulsa's Downtown College.
Residential and Business Districts of Bartlesville		New mercury vapor street lighting.
Public School System of Bartlesville		Complete relighting with fluorescent; cost handled by a city bond issue.

This listing has been compiled by the Local Representatives of Augusta, Ga.; Little Rock, Ark.; and Tulsa, Okla.

glare-free fluorescent . . . nearest to daylight!

Perfected

Best for Schools

IN MITCHELL LOW-BRIGHTNESS LUMINAIRES

MITCHELL engineering develops the maximum advantages of the new low-brightness T-17 lamps in two superior Luminaires . . . at the lowest owning and operating cost per footcandle delivered.* Here is light distribution with absence of glare comparable to daylight conditions. No cross-louvering is required (lowers initial and maintenance costs); provides desirable 40° crosswise cutoff. High light output with low lamp brightness provides ideal illumination for schools, libraries, public buildings and institutions. Modern, functional design is largely self-cleaning. Exclusive MITCHELL mounting features simplify installation. For the best buy in low-brightness lighting, it's wise to specify MITCHELL.

*Ask for revealing Cost Comparison Chart

MODEL NO. 3242.
5-Foot Low-Brightness Luminaire
with Plastic "Lumi-Sides"

MODEL NO. 3245.
5-Foot Low-Brightness Luminaire
with All-Metal Side Panels

CHECK THESE MITCHELL LOW-BRIGHTNESS ADVANTAGES:

Highest Footcandle Output	✓
Glare-free Illumination (surface brightness less than 2 cp/sq. in.)	✓
Lowest Fixture Cost (fewer units, no louvers required)	✓
Lowest Installation Cost	✓
Lowest Maintenance Cost (largely self-cleaning)	✓
Lowest Owning and Operating Cost per Footcandle Delivered	✓
Attractive Functional Design	✓

Write for the complete MITCHELL Commercial Fluorescent Lighting Catalog. Have the full details on MITCHELL Low-Brightness Luminaires, for quick, easy specification.

Mitchell Manufacturing Company, Dept. 3C
2525 N. Clybourn Ave., Chicago 14, Ill.

☐ Please send complete Commercial Lighting Catalog
☐ Please send Cost Comparison Chart

Name _____

Firm _____

City _____ Zone ____ State _____

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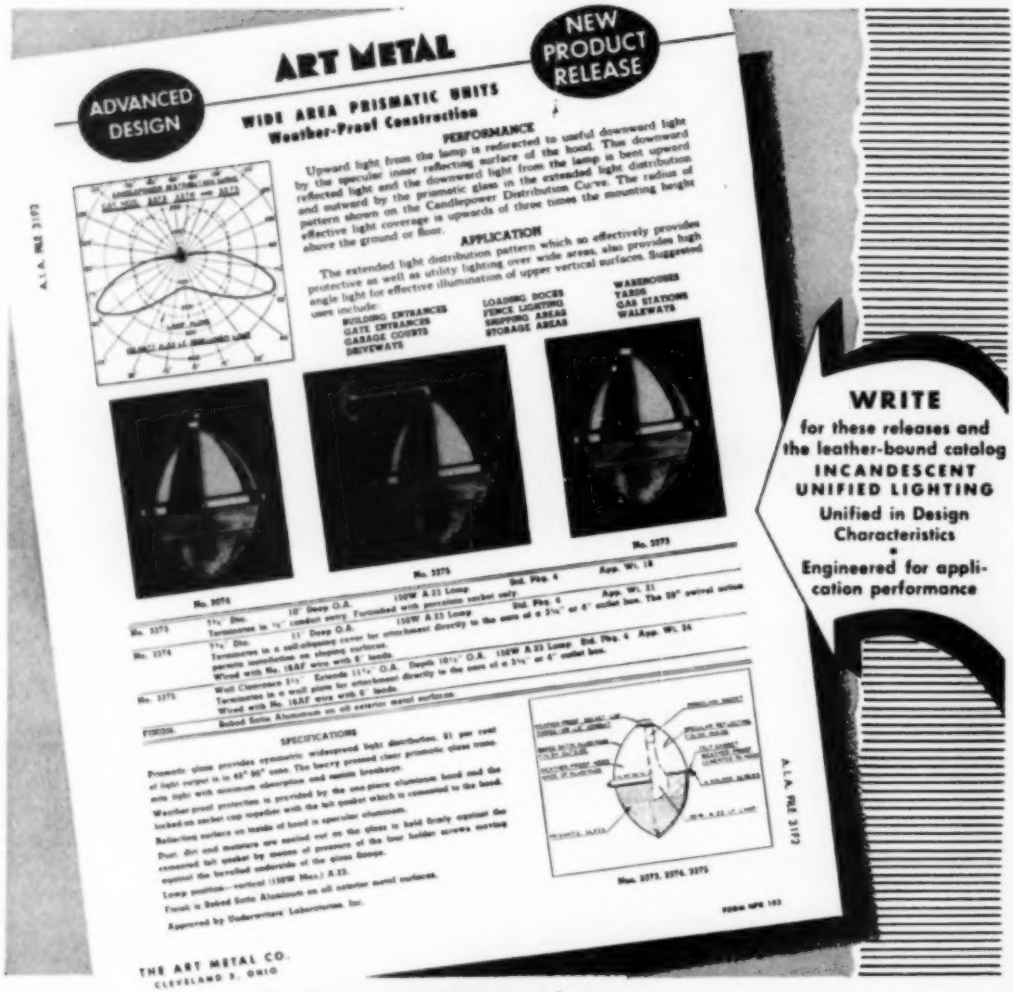
2525 N. Clybourn Avenue, Chicago 14, Illinois
In Canada: Mitchell Mfg. Co., Ltd., 19 Waterman Avenue, Toronto

ART METAL releases

the FIRST of its NEW ideas in

INCANDESCENT LIGHTING



THE ART METAL COMPANY

CLEVELAND 3, OHIO

Manufacturers of Engineered Incandescent Lighting

(Continued from page 14A)

manager of Engineering. **Millard J. Hamner,** continues as member of the administrative staff with general duties outside the engineering area. Other appointees are **Henry F. DeLong,** who replaces Mr. Olson as manager of Lamp Manufacturing and **William E. Davidson,** who fills Mr. Borch's post as manager of Sales Operation.

W. E. White, of Atlanta, Ga., retired early this year after 41 years with General Electric Company. Mr. White was an active member of the Georgia Section, I.E.S., and participated in the early development of the section.

Bernard D. Levaur, vice-president of Pittsburgh Reflector Company, has been named president of the Electric League of Western Pennsylvania for 1952. Other officers elected are: **W. T. Thayer,** vice-president; **R. W. Heller,** secretary; **W. P. Shreve,** treasurer.

H. J. Marquardt, member of the Rochester Chapter, I.E.S., has retired from the General Electric Supply Company after 46 years in the electrical field.

The Illinois Engineering Council, a group representing sixteen engineering societies within that state, announces the election of **J. A. Harrington,** I.E.S. member, as director and second vice-president.

Edward C. Lloyd has been appointed Assistant Chief of the National Bureau of Standards Office of Basic Instrumentation.

Lewis Gordon has been appointed Managing Director of the International Division of Sylvania Electric Products, Inc. This appointment coincided with the conversion of this former sales division into the International Division in care of technical and engineering coordination of operations of foreign affiliates and those of Sylvania.

The appointment of **William E. Francis** as manager of information services of the Lamp Division, Westinghouse Electric Corp., Bloomfield, N. J., has been announced. Mr. Francis will supervise informational activities and community and employe relations programs at all eight plants of the Lamp Division.

Raymond K. Leonard, manager of the Texas Lamp Sales Division of Westinghouse Electric Corp., will be in charge of the new lamp sales and warehouse newly established at 12900 Harry Hines Blvd., Dallas, Texas.

The retirement of **Lee G. Cover** from his position as manager of General Electric Lamp Division's two wire-producing factories has been announced. Mr. Cover was with the company for over 40 years and took a leading part in the development of tungsten wire, used as filaments in electric lamps. He is succeeded by **Herman L. Weiss,** formerly assistant manager.

H. K. Schnetter has been appointed administrative assistant to the manager of the eastern district of Westinghouse Electric Corp.'s Lamp Division and **C. N. Neumann** has been named sales promotion representative. Both men will make their headquarters in the New York Office.

Harry Shearin, of C. W. Cole Co., succeeds **J. H. Lawrence** as Chairman of the Attendance and Reception Committee for the Southern California Section.

OBITUARIES

Edward N. Strait, member of the Chicago Section of I.E.S., died recently from coronary thrombosis. For 34 years Mr. Strait was with Pioneer Service & Engineering Co., in Chicago, retiring in 1950. He was also member of the Western Society of Engineers, the Edison Electric Institute and the American Gas Association.

John P. Des Angles, member of I.E.S. for several years, died January 17 and a resolution of sympathy for his family and friends has been entered in the minutes of the New Orleans Section.

A similar resolution was entered on the death of another member of the New Orleans Section, **J. J. Sanders.**

L. L. Fouraker, Professor of Electrical Engineering at A. & M. College of Texas, and member of the San Jacinto Section, died recently. He is greatly missed by the members of the Section.

Mrs. "Bill" Wuelker, partner in the Wuelker Infra-Red and Lighting Co., passed away January 30, 1952.

NEW MEMBERS

At the meeting of the Council in New York City on February 14, 1952, the following were elected to membership:

ALAMO CHAPTER

Associate Member:
Mecke, R. F., Krause Electric Co., San Antonio, Texas.

BRITISH COLUMBIA SECTION

Associate Members:
Cocking, A. H., B. C. Electric Co. Ltd., Vancouver, B. C.
Gray, W. J., B. C. Electric Railway Co Ltd., Vancouver, B. C.

CAPITAL SECTION

Member:
Angier, J. F., Civil Aeronautic Administration, Washington, D. C.

Associate Members:
Cornbrooks, C. W., Maritime Administration, Washington, D. C.
O'Kelley, Elizabeth, U. S. Department of Agriculture, Washington, D. C.
Semenoff, A. A., 1211-A Connecticut Ave., Washington, D. C.

CAROLINAS CHAPTER

Associate Members:
Alley, C. T., Graybar Electric Co., Asheville, N. C.
Ashmore, J. M., 702 Andrews Bldg., Spartanburg, S. C.

CHICAGO SECTION

Associate Members:
Meyer, Herman, Commonwealth Edison Co., Chicago, Ill.
Rickey, K. R., Curtis Lighting, Inc., Chicago, Ill.
Stoecks, R. C., Mann & Boardown, Chicago, Ill.
Tiedemann, A. T., Chicago Park District, Chicago, Ill.
Wielgos, S. C., Jr., Edward P. Allison & Co., Chicago, Ill.

CLEVELAND SECTION

Associate Members:
Cripe, A. B., Chesapeake & Ohio Railway, Cleveland, Ohio.
Raymond, L. H., Westinghouse Electric Corp., Cleveland, Ohio.
Schultis, J. J., Cleveland Transit System, Cleveland, Ohio.

CONNECTICUT SECTION

Associate Members:
Adams, H. B., Fullerton Mfg. Corp., S. Norwalk, Conn.
Golden, T. M., Electrical Supplies Inc., Hartford, Conn.
Rosen, Malcolm, Grand Light & Supply, New Haven, Conn.

CORNHUSKER CHAPTER

Associate Member:
Stahmer, D. H., Industrial Electrical Works, Omaha, Neb.

EASTERN PENNSYLVANIA SECTION

Associate Members:
Curtin, A. G., Bulldog Electric Products, Laureldale, Pa.
Martens, Wm. H., Martens Mfg. Co., Bethlehem, Pa.

(Continued on page 43A)

I.E.S. National Technical Conferences

September 8-13, 1952—Edgewater Beach Hotel, Chicago, Ill.

Week of September 14, 1953—Hotel Commodore, New York, N. Y.

Week of September 12, 1954—Chalfont-Haddon Hall, Atlantic City, N. J.

COMMITTEES

COMMITTEES 1951-1952

Except as noted below, all committees are appointed by the President, subject to approval of the Council, and terminate at the time of the first Council meeting each new administration, in the month of October. The duties of each committee are indicated.

S. G. Hibben, President, ex officio member of all committees.

STANDING COMMITTEES

BOARD OF FELLOWS — To evaluate the eligibility of candidates for transfer to the grade of Fellow and recommend their election by Council.

Ward Harrison, Chairman, 23475 Stanford Road, Cleveland, Ohio

A. A. Brainerd — E. F. Lowry
Paul H. Goodell — G. F. Mudgett
J. L. Stair

COUNCIL EXECUTIVE — To conduct the affairs of the Society between Council meetings.

S. G. Hibben, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

R. F. Hartenstein — A. H. Manwaring
C. C. Keller — E. M. Strong

FINANCE — Direct supervision of the financial affairs of the Society, present annual report on its financial condition and make recommendations to Council as to investments of money and upon all specific appropriations.

M. N. Waterman, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

W. Warren Booth — R. F. Hartenstein (ex officio)
G. J. Taylor

GENERAL BOARD OF EXAMINERS — Evaluate the eligibility of applicants for admission to membership or transfer to the grade of Member and submit to Council their nominees for elections to the grade of Member Emeritus.

E. M. Fahey, Chairman, Public Service Electric & Gas Co., 80 Park Place, Newark N. J.

George S. Evans — Theo. O. Jorgensen

MEDAL AWARD — To consider qualifications of candidates for I.E.S. Medal; submit recommendations to Council and prepare citation for the award.

Howard L. Wright, Chairman, Curtis Lighting of Canada, Ltd., 195 Wicksteed Ave., Leaside-Toronto, Ont.

E. C. Crittenden — J. L. Stair
C. H. Goddard — Walter Sturrock
G. K. Hardacre — Lee E. Tayler
M. Luckiesh — J. M. Walsh

PAPERS — To procure, review and approve all technical papers and discussions thereof, for presentation before National Conferences of the Society.

L. E. Barbrow, Co-Chairman, National Bureau of Standards, Washington, D. C.

Roy Palmer, Co-Chairman, Duke Power Co., Power Bldg., Charlotte, N. C.

R. M. Zabel, Co-Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

G. W. Beals — J. O. Kraehenbuehl
Roy Dahlin — W. P. Lowell
K. M. Reid

PUBLICATIONS — To be responsible for the procurement, review and approval of all material for the publications of the Society other than technical papers approved by the Papers Committee for presentation at National Conferences of the Society and their discussions and committee reports, for which it will have publication responsibility only. Shall also be responsible for the editing, printing and business management of the publications of the Society.

E. C. Huerkamp, Chairman, Westinghouse Electric Corp., 1216 W. 58th St., Cleveland, Ohio

J. M. Stedman, Vice-Chairman, Pennsylvania Power & Light Co., 901 Hamilton St., Allentown, Pa.

H. H. Magdsick

Sub-Committee on Advertising Sales
J. M. Stedman, Chairman, Pennsylvania Power & Light Co., 901 Hamilton St., Allentown, Pa.

Sub-Committee on Editorial Content
H. H. Magdsick, Chairman, General Electric Co., Nela Park, Cleveland, Ohio

O. P. Cleaver — H. M. Sharp
G. F. Dean — T. H. Shepherd
George Gilleard — T. D. Wakefield
R. W. McKinley — C. W. Zersen

Sub-Committee on Publications Sales
R. W. McKinley, Chairman, Pittsburgh Corning Corp., 307 Fourth Ave., Pittsburgh, Pa.

Sub-Committee on Home Lighting Data Sheets
Edith Buchholtz, Chairman, Westinghouse Electric Corp., Bloomfield, N. J.

Mary Dodds — Thomas S. Kelly
Lillian Eddy — Ruth Morris
F. P. D'Esopo — Aileen Page
Stella Fetzer — Jan Reynolds
Mary Taepke

Sub-Committee on Technical Data Sheets
Eric H. Church, Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.
George T. Anderson, Jr.

Section and Chapter Representatives:
George T. Anderson, Jr. — Paul E. Miller
C. T. Bakeman — J. L. Oglesby
W. P. Beazley — H. J. C. Pearson
R. C. Finn — Harley R. Rector
H. K. Flint — John J. Slevin
Joseph A. Gerber — Dudley T. Smith
Haydn Hargest — H. B. Sohn, Jr.
Harold G. Jones — D. E. Vincent
Arthur H. Lundstrom — Marvin Westrick
G. M. Whittaker

GENERAL COMMITTEES

ADVISORY BOARD ON COMMITTEE PERSONNEL — To examine the organization, accomplishments, and assignments of committees and prepare not later than June 1st of each year a proposed list of committees and personnel.

E. M. Strong, Chairman, Cornell University, Ithaca, N. Y.

C. L. Crouch — A. D. Hinckley
C. H. Goddard — Walter Sturrock

BOARD OF NOMINATION — To prepare a nomination ticket containing the names of those who are deemed best suited to serve as officers and directors in positions to be filled at the ensuing election.

Lee E. Tayler, Chairman, Detroit Edison Co., 1911 First St., Detroit, Mich.

C. H. Goddard — Walter Sturrock
(With Section Representatives)

CONSTITUTION AND BY-LAWS — To prepare for Council amendments to the Constitution and By-Laws as required, and to develop rules of procedure for the operation of the Society.

G. K. Hardacre, Chairman, Public Service Co. of Northern Illinois, 72 W. Adams St., Chicago, Ill.

W. V. C. Foulks — Hoyt P. Steele
Charles N. Laupp — Walter Sturrock
M. N. Waterman

COORDINATING COMMITTEE FOR DEFENSE — To contact various Government Agencies concerned with National Security suggesting cooperation and participation in specific projects as an aid to solution of their problems. Recommending the placement of lighting study projects in present committees or the appointment of study project committees to the Society President and to expedite such study projects and guide accepted reports into proper Government channels.

A. F. Wakefield, Co-Chairman, The F. W. Wakefield Brass Co., Vermilion, Ohio
Major G. D. Mills, Co-Chairman, Department of National Defense, New Army Bldg., Ottawa, Ont.

J. W. Bateman — H. R. Jones
H. R. Blackwell — Paul Manchester
O. P. Cleaver — K. M. Reid
C. L. Crouch — John S. Walsh
S. L. Drumm — M. N. Waterman

Sub-Committee on Artificial Moonlight Project
L. M. N. Bach, Chairman, Tulane University, New Orleans, La.

Mason Guillory — Robert Long
C. J. Sperry

Task Committee #10—Wartime Conservation in Lighting Systems
C. E. Weitz, Chairman, General Electric Company, Cleveland, Ohio.

HISTORICAL — To assemble and make available for current reference and to prepare in suitable and durable form for posterity, such historical facts, printed memorabilia, photographs, voice records, museum specimens and allied items as may be judged worthy of composing a continuing digest of the record of the Society's history.

L. H. Graves, Chairman, Curtis Lighting Inc., 230 Park Ave., New York, N. Y.

George Ainsworth — V. R. Lansingh
R. B. Burton, Sr. — Mrs. W. F. Little
H. B. Dates — Lee E. Tayler
Leo Dolkart — George H. Stickney

LIGHTING AND ARCHITECTURE — To plan an interchange of knowledge and data between the architectural profession and the I.E.S.

W. M. Potter, Chairman, General Electric Co., Nela Park, Cleveland Ohio

H. Creston Doner — Douglas Maier
Ray Hurley — Oscar W. Meissner
Lucian T. Kight — Arthur H. Molitor
J. F. Watkins

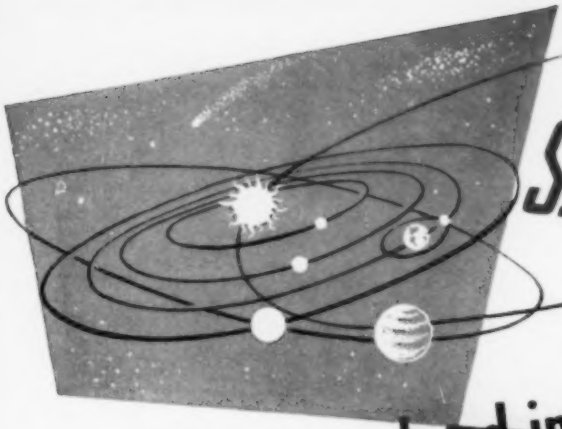
LIGHTING SERVICE — To stimulate the discussion and practical application of lighting recommendations, standards, test procedures and other technical and scientific data developed by the Society to regional and local committees and to conduct a Lighting Service Forum in connection with the National Technical Conference.

Lee E. Tayler, Chairman, The Detroit Edison Co., 2000 Second Ave., Detroit, Mich.

W. E. Folsom — Charles N. Laupp
Paul H. Hildebrand — C. O. Martin
K. E. Hollingsworth — R. Cecil Paslay
F. P. Labey — R. G. Slauer
F. C. Winkler
Chairmen of all Sections and Chapters

LOCAL ACTIVITIES — To coordinate regional and local activities with the national program

(Continued on page 21A)



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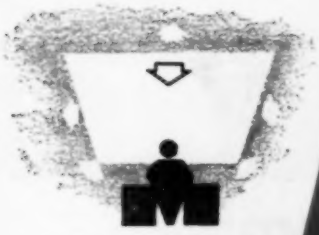
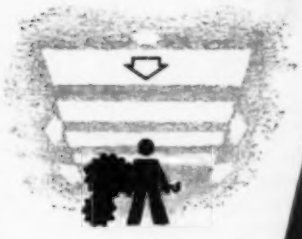


for the office . . . for the store



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LIGHTING DIVISION

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2800-square-foot PLEXIGLAS luminous ceiling in Rohm & Haas Company Engineering Building, Bristol, Pa. Corrugated white translucent PLEXIGLAS is mounted wall-to-wall below continuous runs of fluorescent lamps. Upper window glazing is corrugated gray PLEXIGLAS, for prevention of sky glare.

ENVIRONMENTAL LIGHTING . . . With a PLEXIGLAS Luminous Ceiling

For *environmental* room lighting, the whole field of view must be in brightness balance . . . as in this drafting room with its PLEXIGLAS luminous ceiling.

The surface brightnesses of the ceiling, the walls, and the window areas of this room are less than three times as bright as the paper on the drawing boards. Note how these surfaces produce a field of uniform brightness in which there are no eye-fatiguing light-to-dark contrasts.

An average illumination of 118 footcandles is provided through the PLEXIGLAS diffusing panels, without objectionable direct glare from the large-area ceiling surface.

PLEXIGLAS acrylic plastic offers other advantages as a diffusing medium. Because it is rigid, light in weight, and strong, PLEXIGLAS can be handled easily and safely during installation, cleaning, and relamping operations. And because it is highly resistant to breakage and discoloration, it gives long, low-maintenance service.

If *you* have a lighting problem, investigate *environmental* lighting with a PLEXIGLAS luminous ceiling. We'll be glad to send you full technical details about the installation shown above. Write for them.

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ROHM & HAAS COMPANY

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Canadian Distributor: *Crystal Glass & Plastics, Ltd., 130 Queen's Quay at Jarvis Street, Toronto, Ontario, Canada.*

(*Continued from page 18A*)

of the Society, assist Section and Chapter officers with local operating problems, conduct Local Activities Conferences, prepare plans to give members a better understanding of the Society, review applications for the establishment of new Sections and Chapters and recommend the appointment of local representatives.

A. H. Manwaring, Chairman, Philadelphia Electric & Mfg. Co., 1228 N. 31st St., Philadelphia, Pa.

W. E. Folsom	F. P. Labey
Paul H. Hildebrand	C. O. Martin
K. E. Hollingsworth	R. C. Paslay
Charles N. Laupp	R. G. Slauer

F. C. Winkler

MEMBERSHIP — To develop plans and supervise the operation of the individual membership campaign in the Society.

R. G. Slauer, Chairman, Sylvania Electric Products, Inc., 60 Boston St., Salem, Mass.

Regional Chairmen

Lloyd W. Crotzer

Others to be appointed.

Section and Chapter Representatives

Fred G. Astor, Jr.	D. V. Hileman
Stanley L. Baker	F. P. Larson, Jr.
F. E. Barker	William Lisch
H. A. Bell	Howard Long
Bernard F. Benning	William R. Major
Thomas Bjorge	William G. McCormick
F. E. Blair	Jay Meara
E. H. Biesmer	Leo W. Miles
E. B. Brant	W. A. Newman
J. J. Burns	L. Niemeyer
J. R. Clucas	H. W. Nussbaum
Royal M. Conheady	Robert H. Pippinger
Robert D. Coons	Bernard H. Plante
E. J. Copland	M. S. Prestwood
Chas. E. Corrigan, Jr.	Frank R. Sandy
Lloyd Crotzer	Arthur V. Schafer
Wayne J. Culp	Leonard M. Slusser
Beattie M. DeLong	Anton A. Sobolik, Jr.
R. L. Dennis	William G. Theisner
T. H. Doherty	J. Denis Theriault
Collin Finney	H. S. Thomas
Victor O. Farber	George F. Walter
A. A. Fox	D. Roland Webb
Walter H. Garrett, Jr.	Robert J. Welch
E. D. Heintze	T. C. Wier
V. E. Hendrickson	Harold B. Young

NATIONAL TECHNICAL CONFERENCE — To supervise the 1952 Technical Conference, select the time and place for the 1954 Technical Conference and act as a depository of invitations for future conferences; study and report to Council the possibility of holding periodically a nationally sponsored technical conference for the Pacific Coast Zone.

Hoyt P. Steele, Chairman, Benjamin Electric Mfg. Co., Des Plaines, Ill.

George W. Clark	C. B. Pedersen
G. F. Dean	Ralph G. Raymond
J. C. Forbes	R. G. Slauer
R. F. Hartenstein	Lee E. Tayler
A. D. Hinckley	A. S. Turner, Jr.
Charles N. Laupp	M. N. Waterman

R. M. Zabel

Conference Executive Committee

Ralph G. Raymond, Chairman, Commonwealth Edison Co., 72 N. Adams St., Chicago, Ill.

C. P. Pederson, Vice-Chairman, Illinois Bell Telephone Co., 208 W. Washington St., Chicago, Ill.

Glenn G. Boyd

PROCEDURES AND POLICIES — Analyze for Council current procedures and policies and make recommendations.

Duncan M. Jones, Chairman, Curtis Lighting Co. of Canada, Ltd., 19 Ballantyne Ave., Montreal, Que.

George R. Baumgartner	C. H. Goddard
G. W. Beals	Dana W. Rowten
George S. Evans	Hoyt P. Steele

Lee E. Tayler

PUBLIC RELATIONS AND INFORMATION — To prepare and disseminate information about the activities, accomplishments, programs, objectives and policies of the Society and about the place of illuminating engineering in modern society; to formulate and submit public relations policies and plans for the Society.

J. S. Schuchert, Chairman, Duquesne Light Co., 435 Sixth Ave., Pittsburgh, Pa.

C. E. Albrecht	Roy A. Palmer
Berlon C. Cooper	John H. Ronayne
H. H. Green	G. B. Roscoe
L. A. Hobbs	C. C. Shotwell
James Krieger	R. G. Slauer
L. P. Labey	S. B. Williams

A. F. Wakefield

Section and Chapter Representatives

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Frances Black	George C. Mittauer
Gordon Brown	Robert Morris
Hayden E. Carney	G. T. Nelson
Donald T. Carter	Ira Newman
Brooks Channing	Earl J. Norris
C. O. Christensen	W. F. C. Nottelman
Ralph E. Crockett	C. L. Osborn
R. M. Davis	Henry Osborne
J. Mitchell Davis	Fred S. Perkerson
Harold Eckert	Blair E. Plowman
C. O. Grannis	J. H. Rich
E. L. Hanley	Chauncey W. B. Roby
Theodore S. Harmon	Allan A. Steits
James D. Harrison	J. D. Stephen
Paul E. Keys	T. S. Taylor
Roy H. Kreyser	Edwin H. Voss
Arthur P. Larson	F. S. Walters
Henry Lushington	George A. Watters
R. W. Lyon	Thomas J. Whalen
Brett G. Manlove	Darcie H. White
Charles W. McFee	Edward R. White
H. McMasters	C. S. Witcher

RESEARCH FUND (Solicitation)

S. B. Williams, Chairman, Sylvania Electric Products, Inc., 1740 Broadway, New York, N. Y.

RESIDENCE LIGHTING FORUMS — To reactivate and expand residence lighting forums, suggest programs for meetings, revise Guide for Residence Lighting Forums, and conduct a National Residence Lighting Forum Conference in connection with the National Technical Conference.

Jan Reynolds, Chairman, Sylvania Electric Products, Inc., 1740 Broadway, New York, N. Y.

Jacob Blitzer	Caroline E. Horn
Mary E. Dodds	Robert R. Lusk
Lillian E. Eddy	Ruth Morris
Myrtle Fahabender	Priscilla Presbrey
Mary Love Gale	Margaret Salter

Mary Taepke

SUSTAINING MEMBERSHIP — To obtain additional Sustaining Members.

C. C. Shotwell, Chairman, Philadelphia Electric Co., 1000 Chestnut St., Philadelphia, Pa.

Paul F. Kauffman Walter Wildeman

Regional Representative

Leslie Innis

Section and Chapter Representatives

William A. Biser	R. M. Love
Joe L. Booker	W. J. Montabone
Clinton V. Brown	William C. Mutchler
Cecil L. Cannon	J. C. Nickerson
Eric H. Church	Joe A. Noser
E. E. Coleman	H. V. Oerting
G. Congdon	A. Paulus
Henry J. Damm	Carl L. Powell
Ira G. Deitrick	Harris Reinhardt
Elmore J. Duffy	T. M. Salisbury
John S. Ecclestone	J. R. Smith
E. A. Fargis	R. W. Staal
George G. Fletcher	Frederick A. Stewart
C. K. Fulton	J. Denis Theriault
Edward H. Grieb	Jess D. Thomas
M. Hamilton	L. C. Twitchell
Robert H. Hamilton	Don F. Varner
Elbert A. Hawkins	J. M. Wickett
George M. Hooks	Donald D. Wood
E. W. Hubbs	P. M. Wood

TASK COMMITTEES

TASK COMMITTEE ON ADVANCE PLANNING — To study the operation, program, publication activities, membership classifications and financial structure with a view of its immediate and long-range objectives and to make recommendations to Council.

C. C. Keller, Chairman, Holophane Co., 342 Madison Ave., New York, N. Y.

L. H. Graves	J. E. Mueller
Duncan M. Jones	E. M. Strong
A. H. Manwaring	M. N. Waterman

J. F. Whitehead, Jr.

TRUSTEES, I.E.S. HEADQUARTERS RETIREMENT PENSION PLAN

C. H. Goddard, Chairman, Sylvania Electric Products, Inc., 1740 Broadway, New York, N. C.

R. F. Hartenstein Walter Sturrock

Marshall N. Waterman

TECHNICAL COMMITTEES

AVIATION LIGHTING — To study the application of light and lighting to the spaces and functions involved in the operation of aircraft.

R. C. Blatt, Chairman, McGraw-Hill Publishing Co., 330 W. 42nd St., New York, N. Y.

D. C. Miller, Vice-Chairman-Secretary, General Electric Co., Nela Park, Cleveland, Ohio.

James F. Angier	Charles N. Laupp
F. C. Lahe	A. L. Lewis
J. S. Bartow	D. b. Little
H. R. Blackwell	R. E. Madigan
Frank S. Brady	C. O. Martin
F. C. Breckenridge	N. H. McIntyre
A. H. Clark	W. E. K. Middleton
G. K. Clement	Lewis B. Moore
Harry A. Cramer	R. G.Nordquist
Roy E. Dahlin	R. Cecil Paslay
Irving Fagin	H. J. C. Pearson
W. C. Fisher	W. A. Pennow
W. E. Folsom	T. H. Projector
Kurt Franck	R. A. Rugge
Paul H. Greenlee	L. C. Simpson
J. D. Hall	R. G. Slauer
Paul H. Hildebrand	R. F. Stefany
K. E. Hollingsworth	L. C. Vipond
John P. Hoxie	Martin Warskow
G. M. Kevern	F. C. Winkler
F. P. Labey	A. B. Winters

CIVIL DEFENSE, LIGHTING FOR — To appraise and report on special lighting problems connected with emergency military operations that directly involve civilian defense and protection, such as equipment for bomb shelters, special street and vehicular lighting, mobile self-contained lighting facilities for use in bombed areas, and emergency lighting devices and visual aids to movement in the event of power failure.

L. J. Schrenk, Co-Chairman, Public Lighting Commission, 174 Atwater St., E., Detroit, Mich.

J. W. Bateman, Co-Chairman, Canadian General Electric Co., Ltd., 165 Dufferin St., Toronto, Ont.

Harry Grattan, Vice-Chairman, Potomac Electric Power Co., 10th & E Sts., N. W., Washington, D. C.

John Walsh, Secretary

T. W. Birt	G. D. Mills
R. B. Brown, Jr.	J. C. Nickerson
K. E. Hollingsworth	Kirk M. Reid
R. B. Jackson	R. G. Scott
W. F. Little	T. H. Shepherd

H. E. Stafford

Lighting Advisors for the East Coast

J. C. Forbes, Chairman, General Electric Co., 570 Lexington Ave., New York, N. Y.

Paul Manchester, Vice-Chairman, Blackstone Valley Gas & Electric Co., 55 High St., Pawtucket, R. I.

E. T. Diggs	Roy A. Palmer
S. L. Drumm	R. P. Teele
R. M. Hoot	Frank Wyatt

Lighting Advisors for the West Coast

D. M. Finch K. E. Hollingsworth

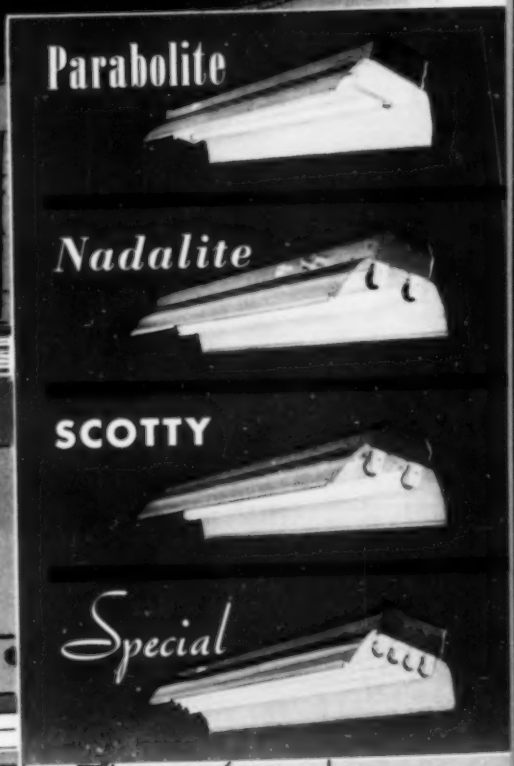
T. H. Shepherd

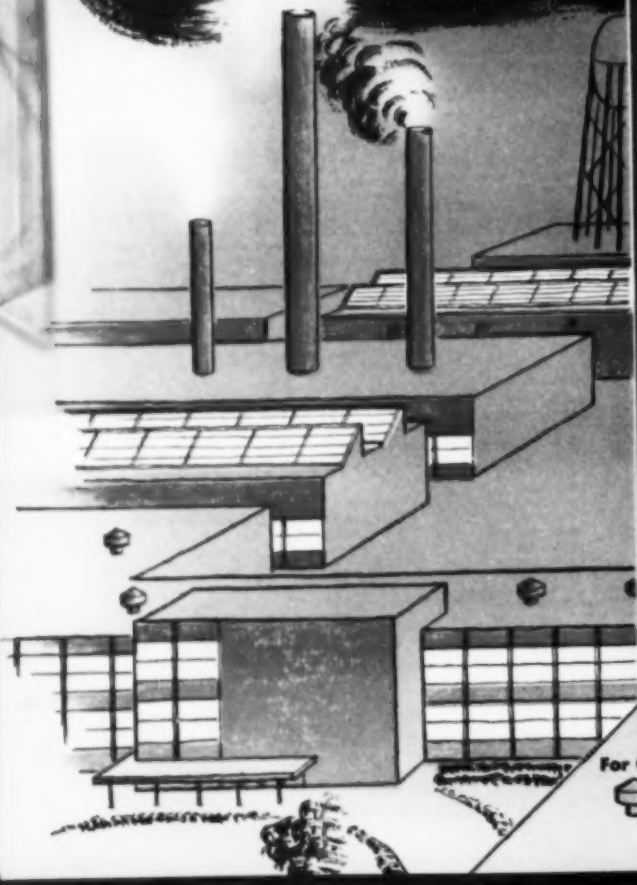
COLOR AND ILLUMINATION — To study, evaluate and report on the effect of color in relation to the art and science of illumination.

Raloh M. Evans, Chairman, Eastman Kodak Company, 65 Kodak Park, Rochester, N. Y.

(*Continued on page 24A*)

Announcing a new line





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A complete new line of more than 150 models in three basic price ranges featuring parabolic reflector for maximum down light . . . normal lamp cut-off of 15°, which is in excess of all laboratory requirements, . . . and toughest possible resistance to oxidation. There are no welded parts—sections are phosphatized and finished before being assembled with plated screws.

finish	models	components
All porcelain, porcelain reflector only, or all hi-baked enamel. Available in all white porcelain or paint on special order.	Two and three lamp conventional and slimline in every lamp wattage from 40 thru 75, four, five, six and eight ft. lengths.	Finest E.T.L. Approved ballasts, starters and turret sockets having 5" lamp spacing.
Satin aluminum enamel with hi-baked white enamel reflector, or porcelain reflector. Available in all white porcelain or paint on special order.	Two and three lamp conventional and slimline, in every lamp wattage from 40 thru 75, four, five, six and eight ft. lengths.	Finest E.T.L. Approved components with conventional white sockets having 3½" lamp spacing.
Satin aluminum enamel with hi-baked white enamel reflector having a reflectance of more than 86%.	Two and three lamp 48" conventional only.	Components are same as Nadalite series except Scotty has shallower channel to accommodate narrow cross-section ballasts.
Satin aluminum enamel with hi-baked white enamel reflector, or porcelain reflector. Available in all white porcelain or paint on special order.	Four lamp conventional and slimline, 48" (4-40 watt) and 96" (4-75 watt or 8-40 watt).	Finest E.T.L. approved components with conventional white sockets.

GIBSON Manufacturing Co.

GIBSON RLM

1919 PIEDMONT CIRCLE, N. E., ATLANTA, GEORGIA

(Continued from page 21A)

R. L. Biesele, Jr. — Harry Helson
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L. M. Brown — H. L. Logan
E. W. Commery — Norman Macbeth
C. L. Cottrell — J. A. Meacham
C. M. Cutler — Gladys Miller
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Dean Farnsworth — S. W. Quisenberry
Carl E. Foss — Frederick Rahr
W. C. Granville — D. E. Spencer
J. P. Guilford — Kenneth C. Welch

DAYLIGHTING — To study the problems involved in daylighting, develop recommended practices and report thereon.

R. L. Biesele, Jr., Chairman, Southern Methodist University, Dallas, Texas

W. J. Arner — J. A. Meacham
R. A. Boyd — E. C. Miles
H. S. Pull — R. A. Miller
W. W. Caudill — D. Reed Muir
E. W. Conover — L. B. Perkins
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Sub-Committee, Standard Test and Report Procedures for Daylight Studies — To develop a standard procedure for conducting and reporting surveys of daylight illuminations for interiors.

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FARM LIGHTING *(Formerly Farm Buildings and Work Area Lighting)* — To study the application of light and lighting of farm buildings, surrounding work areas and other rural locations and to report thereon.

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INDUSTRIAL LIGHTING — To revise the 1942 "American Recommended Practice of Industrial Lighting" with full consideration to the brightness approach, and with Council approval, to submit for American Standards Association approval.

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LIGHT SOURCES — To correlate and report available information as to the physics of light and light production and the characteristics of current light sources.

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LIGHTING DESIGN PRACTICE — To study published data on coefficients of utilization, room indexes, maintenance coefficients and other elements entering into calculations for lighting design, develop standard methods for use in Society publications and report thereon.

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LIGHTING MAINTENANCE — To study the elements contributing to maintenance factors; set up the framework of typical field studies to determine factors; and to stimulate the prosecution of such studies by appropriate agencies.

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(Continued on page 27A)

For a stimulating abundance of light

The *Wakefield* (fluorescent)

GRENADIER

W. E. Gilbert, Plumbing and Heating, West Chester Pa. Wakefield Grenadiers with Spots; 10'0" o.c; 5" suspension.

John Fitzpatrick Self-Service Store in West Chester, Pa. Wakefield Pacemakers, 7' 6" o.c; on ceiling mounting.

For quality performance at a low price

The *Wakefield* (fluorescent)

PACEMAKER

Lighting counselors of the Philadelphia Electric Company achieved a fine degree of lighting effectiveness in these two store installations. The Gilbert Store measured 50 footcandles throughout, with 125 footcandles under the Spots, the Fitzpatrick Store 65 footcandles, each measured after 300 hours of operation.

Wakefield Grenadiers and Pacemakers are of a popular louvered design that provides a direct-indirect light distribution. They give effective over-all illumination, and at the same time lend a sparkle to merchandise that stimulates customer interest. Louvers provide 35° shielding normal to the lamps and 25° parallel.

Each type of luminaire is available in stem, canopy, and on-ceiling models, in four or eight-foot units or in continuous runs. They're designed for easy installation (a one-man job!) and are economical to maintain.

Wakefield Over-ALL Lighting

KEEP LIGHTING EFFICIENCY UP!

with New
JEFFERSON TRANSFORMERS
For Mercury Vapor Lamps

Correctly and specifically designed for modern lighting service—Jefferson Transformers provide the proper starting and safe operating voltage and current for long-life, lowest cost lamp performance. They are made in types for pole or wall mounting, pole top, pole base or vault installation.

Designed by transformer specialist engineers and by a company that has devoted over 35 years to this one type of product — these transformers keep your mercury lamp lighting efficiency up and maintenance down.

NOTE THESE IMPORTANT FEATURES

- Accuracy of design for correct control of voltage and current.
- Deep drawn, one-piece steel case galvanized and finished with weatherproof paint.
- Flexibility—The same transformer may be used for mounting on a wall or pole—*and by means of an Adaptor fits any pole top from 2½-in. to 4-in. diameter.* Reduces stock to be carried.
- Types for areas where temperatures reach below 20°F. 300-volt open secondary insures starting the lamp.
- Selection of *three* primary voltage taps to permit close matching of circuit voltage for the best possible lamp performance.

For complete specifications, details and mounting recommendations, write for new Bulletin 521-5.

Transformers for multiple or series circuits may be mounted on pole or wall.

Some type transformer with Adaptor for pole-top mounting. Adaptor fits any pole from 2½-in. to 4-in. diameter.

JEFFERSON ELECTRIC COMPANY • Bellwood, Illinois

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(*Continued from page 24A*)

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PROTECTIVE LIGHTING — To prepare standards for protective lighting of plants, yards, boundary fences, adjoining highways, railroad sidings, and waterway approaches for the purpose of reducing fire and theft risks, and making policing more effective.

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(*Continued on page 31A*)

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KOPP GLASS

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(Continued from page 27A)

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(Continued on page 34A)

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(Continued on page 37A)

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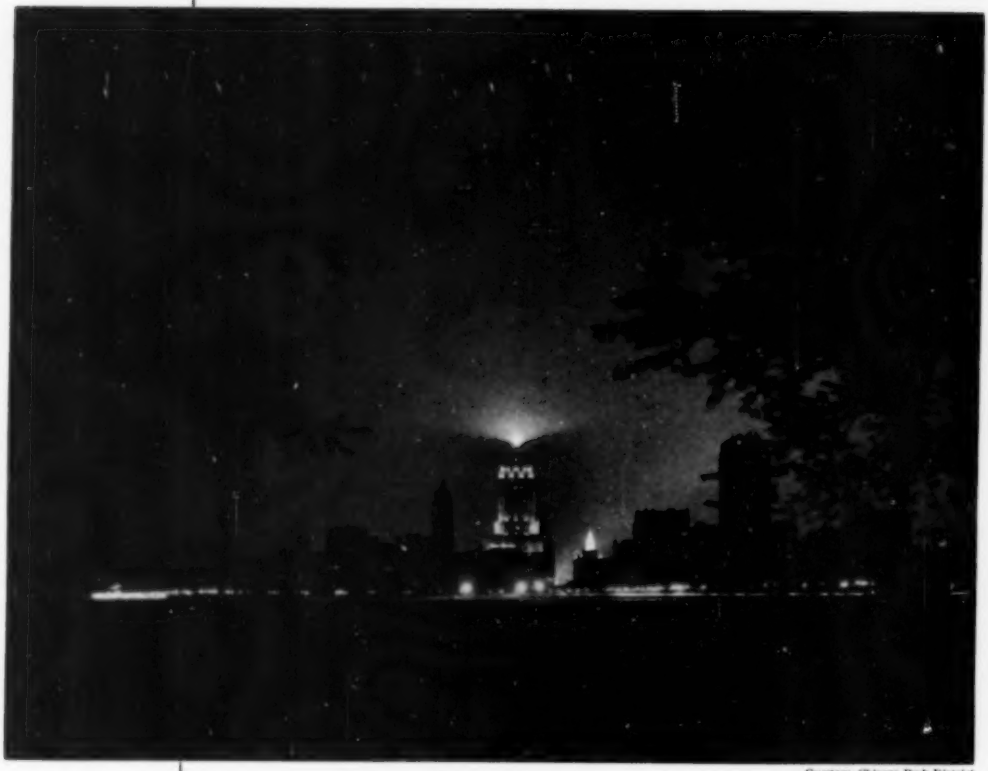

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CHICAGO NATIONAL TECHNICAL CONFERENCE
SEPTEMBER 8-12, 1952, EDGEWATER BEACH HOTEL
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(Continued from page 34A)

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Lansing, Mich.—John D. Malnight, Board of Water & Light.
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Lockport, N. Y.—Tunis E. Barhite, Jr., N. Y. State Electric & Gas Corp.
Manistee, Mich.—Lewis Neuruberger, Consumers Power Co.
Mansfield, Ohio—Orlo L. Smith, Ohio Public Service Co.
Marion, Ohio—LeRoy W. Clauer, Ohio Public Service Co.
Massillon, Ohio—Jesse R. Parsons, Ohio Public Service Co.
Monroe, Mich.—Keith E. Hunt, Detroit Edison Company.
Newark, Ohio—Kurt Franck, Holophane Co. Inc.
Niagara Falls, N. Y.—Francis J. Wilcox, Niagara Mohawk Power Corp.
Port Huron, Mich.—James Abernethy, Detroit Edison Company.
Saginaw, Mich.—Earl R. Domoney, Consumers Power Company.
Sandusky, Ohio.—C. H. Smith, Ohio Public Service Company.
Toledo, Ohio—Charles Hoffman, Peterson, Hoffman & Barber.
Traverse City, Mich.—H. E. Davis, Consumers Power Co.
Warren, Ohio—Walter C. Schultz, Ohio Public Service Co.
Johnstown, Pa.—Howard E. Ross, RD 4, Box 82.
Kingston, Pa.—John G. Henninger, P.O. Box 1348.

(Continued on page 38A)

(Continued from page 37A)

Lancaster, Pa. — Ford M. Gochenauer, Pennsylvania Power & Light Co.
Lebanon, Pa. — Charles C. Russell, Jr., Metropolitan Edison Co.
Lexington, Va. — J. S. Jamison, Jr., Virginia Military Institute.
Morgantown, W. Va. — William C. Wade, Monongahela West Penn Public Service Co.
New Castle, Pa. — R. L. James, Pennsylvania Power Co.
Youngstown, Ohio — Robert Zimmerman, Ohio Edison Company.

Midwestern Region

Ames, Iowa — Warren B. Boast, Iowa State College.
Cedar Rapids, Iowa — J. C. Young, Jr., 2400 "E" Avenue, N. E.
Davenport, Iowa — Fenn C. Horton, General Electric Company.
Des Moines, Iowa — George G. Fletcher, 3103 University Avenue.
Dubuque, Iowa — Harold E. Rucks, Interstate Power Company.
Duluth, Minn. — M. G. Braden, Minnesota Power & Light Co.
Eau Claire, Wisc. — S. R. Gram, Northern States Power Co.
Evansville, Ind. — Ned S. Muse, Graybar Electric Co.
Evansville, Ind. — R. M. Sly, Southern Indiana Gas & Electric Co.
Faribault, Minn. — C. J. Aas, Northern States Power Co.
Ft. Wayne, Ind. — N. G. Smoley, General Electric Company.
Green Bay, Wisc. — C. E. Lageman, Wisconsin Public Service Corp.
Independence, Kans. — H. J. Winters, Kansas Gas & Electric Co.
Independence, Mo. — R. S. Everitt, 107 E. Southside Blvd.
Joplin, Mo. — Charles Wells, Empire District Electric Co.
Kansas City, Kans. — J. R. Foley, W. F. Foley Electric Co.
La Crosse, Wisc. — C. L. Seaquist, Northern States Power Co.
Lawrence, Kans. — Glen E. Razak, Kansas Power & Light Co.
Madison, Wisc. — Prof. L. C. Larson, University of Wisconsin.
Manhattan, Kans. — Prof. O. D. Hunt, Kansas State College.
Mankato, Minn. — Kenneth H. Kraus, Southern Minnesota Supply Co.
Mason City, Ia. — Benton O. Horton, Mason City, Ia.
Muncie, Ind. — John A. Hand, Indiana & Michigan Electric Co.
North Kansas City, Mo. — Charles Owsley, No. Kansas City Electric Co.
Peoria, Ill. — George Feldkamp, Crescent Electric Co.
Peoria, Ill. — James F. Orr, Jr., General Electric Company.
Pittsburgh, Kans. — Carl Liebig, Kansas Gas & Electric Co.
Richmond, Ind. — A. E. Bailey, 12 S. 11th St.
Rockford, Ill. — S. Cuxhead, Central Illinois Electric and Gas Co.
Rochester, Minn. — Donald H. Nietz, 30 Seventh Avenue.
St. Cloud, Minn. — Wallace Thometz.
St. Joseph, Mo. — S. J. Roberts, St. Joseph Light & Power Co.
Sioux Falls, S. D. — G. William Frederick, Sioux Falls, S. D.
South Bend, Ind. — Prof. L. F. Snyder, 802 St. Vincent St.
Streator, Ill. — H. W. Knight, Public Service Co. of No. Illinois.
Topeka, Kans. — S. D. Thacher, Overton Electric Co., Inc.
Urbana, Ill. — Prof. J. O. Kraehenbuehl, University of Illinois.
Waterloo, Iowa — J. C. Gehan, 711 Lime Street.
Wausau, Wisc. — G. M. Kammerer, Wisconsin Public Service Corp.
W. Lafayette, Ind. — Warren Kenke, Purdue University.
Wichita, Kans. — A. L. Harris, Kansas Gas & Electric Co.

Northeastern Region

Albany, N. Y. — C. E. Waldron, Niagara Mohawk Power Corp.
Asbury Park, N. J. — David J. Douglas, Jersey Central Power & Light Co.
Augusta, Me. — Raymond B. McFarland, Central Maine Power Co.
Bangor, Me. — Wilbur D. Chadeayne, Bangor Hydro Electric Co.
Bridgeport, Conn. — Kenneth Priestley, The Eastern Electric Construction Co.
Dover, N. J. — John W. Haynes, New Jersey Power & Light Co.
Essex, Conn. — John V. Fratus, Jr., Connecticut Light & Power Co.
Greenfield, Mass. — Collen H. Kilburn, Western Massachusetts Electric Co.
Lowell, Mass. — Frank H. Jones, The Lowell Electric Light Corp.
Mineola, N. Y. — J. F. Dickerhoff, Long Island Lighting Co.
Morristown, N. J. — George L. Estler, Jersey Central Power & Light Co.
New Britain, Conn. — Timothy J. Clare, 376 Chestnut St.
New Haven, Conn. — Fred R. West, Westinghouse Electric Corp.
Norwalk, Conn. — H. A. Hutchinson, Connecticut Light & Power Co.
Pawtucket, R. I. — Walter L. Kelley, Jr., 77 Bayley Street.
Poughkeepsie, N. Y. — Taylor M. Barr, Central Hudson Gas & Electric Corp.
New York, N. Y. — Prof. Abraham Abramowitz, The City College of New York.
Portland, Me. — P. E. Weatherbee, Central Maine Power Co.
Rutland, Vt. — George Blackburn, Central Vermont Public Service Corp.
Springfield, Mass. — Jack O. Callander, Western Massachusetts Electric Co.
Waterbury, Conn. — R. O. Mills, 19 Maynard Avenue.
Worcester, Mass. — W. S. Mowry, Worcester County Electric Co.

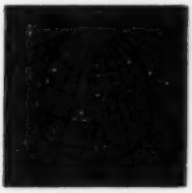
Pacific Northwest Region

Bellingham, Wash. — Phil T. Rosser, Puget Sound Power & Light Co.
Billings, Mont. — George K. Alm, General Electric Supply Co.
Butte, Mont. — John W. Cromer, Montana Power Company.
Coulee Dam, Wash. — T. R. Anderson, U. S. Bureau of Reclamation.
Eugene, Ore. — J. Francis Whitney, Eugene Water & Electric Board.
Everett, Wash. — C. V. Harlander, Snohomish County P.U.D. #1.
Great Falls, Mont. — Leonard R. Regan, Montana Power Company.
Gresham, Ore. — D. A. Maulding, Portland General Electric Co.
Hillsboro, Ore. — C. H. Winjum, Portland General Electric Co.
Newberg, Ore. — Floyd O. Miller, Portland General Electric Co.
Olympia, Wash. — Gordon G. Cochran, P.O. Box 334.
Oregon City, Ore. — F. C. Henkel, 1601 Madison Street.
Pendleton, Ore. — Don F. Miller, Charles B. Miller, Architect.
Salem, Ore. — James L. Hunt, Jr., Portland General Electric Co.
Tacoma, Wash. — Charles W. Vollrath, General Electric Co.
Trail, B. C. — Thomas Emes, Emes Electric Company.
Victoria, B. C. — Percy F. Fletcher, Canadian General Electric Co., Ltd.
Walla Walla, Wash. — Frank Gage, 825 S. Palouse.
Wenatchee, Wash. — R. F. Watt, Public Utility District #1 of Chelan County.
Winslow, Wash. — Frank D. Drebick, Puget Sound Power & Light Co.

Southern Region

Anniston, Ala. — D. A. Springer, 22 E. 12th Street.
Asheville, N. C. — Harry W. Schusler, 600 New Medical Building.
Athens, Ga. — R. A. Arthur, Georgia Power Company.
Augusta, Ga. — Walter S. Smith, Jr., Georgia Power Company.
Baton Rouge, La. — J. A. Stelly, Gulf States Utilities.
Birmingham, Ala. — Elwyn B. Richey, Comer Building.
Charleston, S. C. — Arthur R. Moore, South Carolina Power Co.
Charlotte, N. C. — Hamilton Corey, Graybar Electric Co., Inc.
Chattanooga, Tenn. — Buford H. Martin, Tennessee Valley Authority.
Columbia, S. C. — W. B. Southerlin, State Educational Finance Comm.
Columbus, Ga. — W. D. Hannah, Georgia Power Co.
Coral Gables, Fla. — William H. Morris, Lowry Electric Co. Inc.
Durham, N. C. — S. B. Harper, Duke Power Co.
Fitzgerald, Ga. — Dr. J. D. McCord, 115 S. Main St.
Florence, Ala. — Robert C. Willis, 1350 James St.
Ft. Lauderdale, Fla. — Walter H. Dance, Broward Electric Service Inc.
Greensboro, N. C. — J. W. Welch, Duke Power Co.
Greenville, S. C. — Joseph A. Keller, Jr., Sylvania Electric Products Inc.
Griffin, Ga. — John B. Walton, Walton Electric Co.
Hollywood, Fla. — A. O. Wickham, Florida Power & Light Co.
Jackson, Miss. — T. M. Salisbury, Gregory-Salisbury & Co.
Kingsport, Tenn. — J. B. Carson, Kingsport Electric Co. Inc.
Knoxville, Tenn. — Leslie B. Pierson, Knoxville Utilities Board.
Lafayette, La. — John R. Gaugler, Gulf Public Service Co.
Lithonia, Ga. — James M. Russell, Lithonia Lighting Products Co.
Macon, Ga. — W. T. Cantrell, Georgia Power Company.
Mandarin, Fla. — J. N. Crevasse, Drawer 7.
Marietta, Ga. — P. N. Littlefield, Champion Lamp Company.
Memphis, Tenn. — John W. Gilchrist, Box 2833, Desoto Station.
Miami Beach, Fla. — S. G. Kent, Florida Power & Light Co.
Milledgeville, Ga. — William F. Humbert, M. T. Stevens Southern.
Mobile, Ala. — J. D. Terrill, McGowin-Lyons Hardware & Supply Co.
Montgomery, Ala. — C. D. Parker, Alabama Power Co.
Nashville, Tenn. — Collin Finney, 4050 Outer Drive.
Raleigh, N. C. — W. P. McPherson, Carolina Power & Light Co.
Rome, Ga. — W. T. Tucker, 105 Charlton Road.
Savannah, Ga. — W. C. Matthews, Savannah Electric & Power Co.
Spartanburg, S. C. — Paul T. Tysinger, Duke Power Co.
State College, Miss. — Prof. H. C. F. Simrall, Mississippi State College.
West Point, Ga. — Charles R. Williams, West Point, Ga.
Wilmington, N. C. — Clyde E. King, Tidewater Power Company.

(Continued on page 47A)



LIGHTING EFFICIENCY

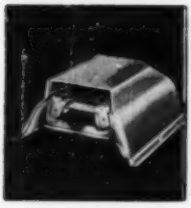
35° crosswise, 41° lengthwise shielding combined with high utilization.

Choose THE NEW 5500 SERIES GARY recessed troffers

...because of these "ENGINEERED-IN" features

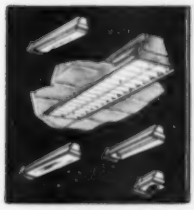
ONE PIECE LOUVER

Punched and formed in one piece with continuous outer frame for lasting rigidity. New, simplified hinging reduces maintenance.



UNIQUE COUPLING PLATE

- Lets light pass from one unit to next for more uniform brightness throughout the run.
- Wide open wireway for fast splicing.
- Simple, bolt-together coupling.



VERSATILITY

- For any type ceiling.
- 1, 2 or 3 lamp rows.
- 4, 6 or 8 ft. lengths.
- Standard fluorescent or slimline.
- Varied bottom treatments, including louvers, diffusing glass, flat or curved lenses.
- Matching Spot-a-Lites available.

GARDEN CITY PLATING and MFG. COMPANY
1760 North Ashland Avenue
CHICAGO 22, ILLINOIS

How to make these ads work for you

THE General Electric lamp ads, above, all feature Light Conditioning. They have run in full color in big-circulation magazines like The Saturday Evening Post, Better Homes & Gardens and Ladies' Home Journal. They are selling millions of home-makers—including many in your own service area—on the benefits of Light Conditioning.

These advertisements, and the continuing series of Light Conditioning ads to follow, can help to improve lighting standards in *your* area—if you tie in with a Light Conditioning program of your own.

For full information on how to plan a Light Conditioning program, call your G-E lamp District Office, or write Lamp Division, General Electric Company, Nela Park, Cleveland 12, Ohio.

GENERAL ELECTRIC

A BETTER FIXTURE FOR EVERY LIGHTING NEED... from

Leader

...ality Fixtures for ...

THE OFFICER

America's finest fluorescent fixture for interiors of distinction. Streamlined and gracefully proportioned. Translucent plastic side panels, one-piece injection moulded plastic louver with choice of 31° or 45° shielding. For two, three or four 40-watt lamps, or Slimline lamps in lengths from 48" to 96".

THE STRATOLINER

This heavy-duty, all-steel unit offers everything desired in an industrial fixture. Durable, strongly built, neat in appearance, easily serviced. Reflector finished in baked enamel or porcelain enamel (RLM approved). Available in open or closed end style for two or three 40-watt lamps, or two 85-watt lamps.

RECESSED TROFFERLITE

Leader troffer fixtures offer versatility of lighting design and high light values. Shown here with matching incandescent spotlight. Trofferlites are available with a wide variety of glass or specialized lenses, also in louvered, baffled and open styles. Complete range of lengths, choice of regular or shallow depth, 12" or 24" width, for from two to eight lamps.

Sold and installed by the better electrical dealers and contractors

Leader® America's No. 1 Lighting Equipment Manufacturer

LEADER ELECTRIC COMPANY • 3500 North Kedzie Avenue • Chicago 18, Illinois

Leader Electric—Western: 800 One Hundredth Avenue, Oakland 3, California

Campbell—Leader, Ltd.: Brantford, Ontario, Canada

NEW MEMBERS

(Continued from page 17A)

Odenweller, Willard, Metropolitan Edison Co., Easton, Pa.
Riddell, J. W., Graybar Electric Co., Reading, Pa.

FLORIDA CHAPTER

Member:
Alfonso, M. J., 2302 Ardson Place, Tampa, Fla.
Associate Member:
Haskin, Donald, Ormond Electric Co., Ormond Beach, Fla.

FOREIGN NON SECTION

Associate Members:
Swi-ntra, R., Harddraverslaan 17, Santpoort, Holland.
Venning, R. R., Philips Electrical Ltd., London W.C. 2, England.
Student Member:
Chisholm, P. F., Philips Electrical Industries of New Zealand Ltd., Wellington, c 1, New Zealand.

GEORGIA SECTION

Associate Members:
Majors, J. P., Graybar Electric Co., Atlanta, Ga.
Myers, Miss Naomi, Southern Engineering Co., Atlanta, Ga.
Pearson, W. M., Graybar Electric Co., Atlanta, Ga.

HEART OF AMERICA SECTION

Associate Members:
Krall, J. L., Sylvania Electric Products Inc., Kansas City, Mo.
Vaughn, L. A., Sylvania Electric Products Inc., Kansas City, Mo.

INDIANA CHAPTER

Member:
Zeller, J. C., Indiana & Michigan Electric Co., Ft. Wayne, Ind.

INLAND EMPIRE CHAPTER

Associate Member:
Aichlmayr, A. F., Washington Water Power Co., Davenport, Wash.

MARYLAND SECTION

Associate Members:
Beissler, B. A., Electrical Distributing Co. Inc., Baltimore, Md.
Langeluttig, E. M., Lee Electric Co. of Baltimore City, Baltimore, Md.

MICHIGAN SECTION

Associate Member:
Faren, S. A., Graybar Electric Co., Detroit, Mich.

MILWAUKEE SECTION

Associate Members:
Engel, A. L., 2138 S. 25th St., Milwaukee, Wis.
Shepard, E. B., Moe Brothers Northern Co., Appleton, Wis.
Shipla, Jay, Moe Bros. Northern Co., Appleton, Wis.
Stubbe, Robert, Wisconsin Electric Co., Milwaukee, Wis.
Wilsens, L. A., Herman Andrae Electrical Co., Milwaukee, Wis.

MISSISSIPPI CHAPTER

Associate Members:
Cook, Hartwell, General Electric Co., Jackson, Miss.
Hickman, L. H., General Electric Co., Jackson, Miss.
Johnson, M. D., Cabell Electric Co., Jackson, Miss.
O'Steen, J. E., Westinghouse Electric Supply Co., Jackson, Miss.
Williams, J. H., Joe Williams Electric Co., Jackson, Miss.

MONTREAL SECTION

Associate Members:
Frick, D. W., Canadian Broadcasting Corp., Montreal, Que.
Kuzniar, Chester, The Holophane Co., Ltd., Montreal, Que.

NEW ENGLAND SECTION

Associate Members:
Pucci, J. E., Pucci Electric Co., Westerly, R. I.
Rosen, J. G., 25 Edgemont St., Roslindale, Mass.
Small, K. G., Central Maine Power Co., Waterville, Maine.

NEW ORLEANS SECTION

Members:
Bailey, H. T., Jr., Louisiana Power & Light Co., Gretna, La.
Gregory, H. S., Gregory & Salisbury & Co., New Orleans, La.
Levy, A. A., Interstate Electric Co., New Orleans, La.

NEW YORK SECTION

Associate Members:
Grayson, Paul, Neptune Storage Co., New Rochelle, N. Y.
Rosenfeld, E. J., Gotham Lighting Corp., Long Island City, N. Y.

NORTHERN CALIFORNIA SECTION

Associate Member:
Benton, R. P., Pacific Gas & Electric Co., Oakland, Calif.
Student Members:
Kopsho, J. D., Jr., Stanford University, Stanford, Calif.
Pratt, Dustinn, Stanford University, Stanford, Calif.
Ritchey, J. E., Jr., Stanford University, Stanford, Calif.
Rowton, L. R., Stanford University, Stanford, Calif.

NORTHWESTERN OHIO CHAPTER

Associate Member:
Hallett, A. W., Graybar Electric Co., Toledo, Ohio.

OHIO VALLEY SECTION

Associate Member:
Johnson, I. L., American Radiator & Standard Sanitary Corp., Louisville, Ky.

(Continued on page 44A)

ANOTHER ABOLITE FIRST!

New ABOLITE ALL-PURPOSE Yardlite!

A new idea in reflectors! The new ABolite All-Purpose YARDLITE is a complete unit ready to install either *outside or inside.*

Packed with each YARDLITE reflector are pipe, elbow and bracket for outdoor installation, *plus* flat mounting plate for indoor installation.

If at any time you want to switch the light from outside to inside, or vice-versa—simply change the mounting bracket. Nothing extra to buy—no fuss, no bother. YARDLITE offers *more value* because it has *more uses.*

YARDLITE is available in 12" and 14" reflectors—finished in ABolite Lifetime Porcelain Enamel—popular "Whiter than White" inside, forest green outside.

Write today for full information!

ABOLITE SERVICE

There is a complete field staff of ABolite lighting experts to serve you. When you buy ABolite you get:

- Extra customer service
- Fast Delivery
- Personal attention to your orders

ABOLITE Lighting DIVISION

THE JONES METAL PRODUCTS CO., West Lafayette, O.

one thousand and one reasons why
over 10,000 will attend . . .
"The facts and data that I pick up about the latest developments and advances in lighting equipment are invaluable to me in selling my lighting lines."
"I am in the market for some new lighting equipment in one of my buildings and I hope to find the answer to my needs at the Exhibits of the lighting equipment manufacturers."
"As an electrical contractor, the new ideas I pick up on PLANNED LIGHTING help me in my business."
"As a utility man, I am interested in all the aspects of Planned Lighting and I know of no better place to get all the latest dope than at the Lighting Exposition."
"I think every architect will find the new techniques and equipment displayed and described at the Exposition, a big help in planning lighting."
"I am particularly interested in seeing the winning Case Studies in the Merit Award Competition."

4th International LIGHTING EXPOSITION and conference

See for Yourself How Lighting Knowledge Can Help You . . . Your Industry . . . and Advance America's Welfare

Since the Third International Lighting Exposition, in March of 1949, much has happened in the lighting industry. You can find out what has happened and what's ahead in lighting at the Fourth International Lighting Exposition. Here, at one great Exposition and Conference, you will see the latest in the world of lighting... you will see and hear how to plan and use the latest lighting knowledge in your work. See the latest advances and developments in Planned Lighting for all kinds of businesses, industries, schools, theaters, service stations, airports, play areas, etc. Hear and meet leading manufacturers and authorities on lighting to learn what is ahead in the science of illumination. You can get all of this in Cleveland in four, big, action-packed days.

The program committee has lined-up an impressive list of speakers—all leading authorities on their own phase of the lighting industry. Plan now to attend—send the coupon below for your Free Advance Registration. Avoid waiting in line.

. . . See the *Merit Award Winners in a Bigger than Ever Court of Honor*

As in previous International Lighting Expositions, one of the highlights of the show will be the awarding of the Merit Award Certificates and the Gold Seal Merit Award Certificates to the winners in the big 1952 Merit Award Competition. All the winners and many other Case Studies will be put on display in the spacious Court of Honor for you to study.

There will be more and bigger exhibits than ever before by outstanding lighting equipment manufacturers and manufacturers of allied products. You will find the greatest array ever gathered under one roof of industrial and commercial lighting fixtures for incandescent and fluorescent lamps . . . plastic, glass, paint and allied products that are of definite interest to lighting people.

CLEVELAND MAY 6-9, 1952

Early Bird
APPLICATION FOR FREE ADVANCE REGISTRATION

to the Fourth International LIGHTING EXPOSITION MANAGEMENT
511 Terminal Tower, Cleveland, Ohio

NO WAITING IN LINE
Please mail this coupon

Without obligation, I wish to apply for free Advance Registration at the FOURTH INTERNATIONAL LIGHTING EXPOSITION and CONFERENCE.

My badge of admission to Exhibit Hall is to be ready for me when I call for it at the Registration Desk and there will be no waiting

NAME _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____

COMPANY _____

MY POSITION IS _____

THE FOURTH INTERNATIONAL LIGHTING EXPOSITION is sponsored as a public service by the Industrial and Commercial Lighting Equipment Section of the NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION.

5750

There will always be someone to build them CHEAPER but...

. . . it takes SKILL and EXPERIENCE to build them BETTER!

Every manufacturer, regardless of the product he makes, knows that in one way or another it is possible for one of his competitors to reduce the quality of the product and sell it at a lower price. This is especially true in the manufacturing of products in which the performance can only be exactly demonstrated with scientific instruments. For example: a fluorescent lamp ballast, alleged by the manufacturer, name plate to be a dual 40 watt design, but which actually delivers 31.1 watts on the leading circuit and 39.6 watts on the lagging circuit and has a power factor of only 85.3% is far below the minimum standards required for proper lamp operation. Ballasts with such sub-standard characteristics should be sold at scrap prices—not at merely a few cents below the price of good ballasts.

We invite manufacturers who want to build quality fixtures to visit our plant and to see for themselves how Acme Electric ballasts are constantly being improved thru research, how they are produced economically by modern manufacturing methods, how each and every ballast is tested, to show you our salvage department, which separates the copper, steel and compound for the scrap market. Sure, we make a few mistakes—but we don't sell them.

ACME ELECTRIC CORPORATION
293 WATER ST. CUBA, NEW YORK

Acme ACME Electric
TRANSFORMERS

NEW MEMBERS

(Continued from page 42A)

Student Member:
Campbell, R. L., Cincinnati Gas & Electric Co., Cincinnati, Ohio.

OKLAHOMA CHAPTER

Associate Member:
Shamas, Ray, Circle "L" Electric Co., Tulsa, Okla.

OREGON SECTION

Associate Members:
Carney, H. M., Jr., Portland General Electric Co., Newberg, Ore.
Lowry, R. M., General Electric Co., Portland, Ore.

Student Members:
Seid, Robert, Oregon State College, Corvallis, Ore.
Sein, M. M., Oregon State College, Corvallis, Ore.

OTTAWA CHAPTER

Associate Members:
Bowie, F. G. C., F. G. Bowie & Sons, Ottawa, Ont.
Copeland, L. M., Morlen Electric Ltd., Ottawa, Ont.
Dupuis, L. C., Canadian Westinghouse Co. Ltd., Ottawa, Ont.

PHILADELPHIA SECTION

Member:
Hawkins, W. E., Atlantic City Electric Co., Atlantic City, N. J.

Associate Members:
Corak, B. J., 1631 Winter St., Philadelphia, Pa.
Faulkner, P. H., Jr., Sylvania Electric Products Inc., Philadelphia, Pa.
Hufnagel, J. G., Philadelphia Electric Co., Philadelphia, Pa.
Kelly, A. M., American Stores Co., Philadelphia, Pa.
King, J. P., Westinghouse Electric Corp., Philadelphia, Pa.
Taylor, W. G., Philadelphia Electric Co., Philadelphia, Pa.

PITTSBURGH SECTION

Member:
Kuhlmann, G. H., General Electric Co., Pittsburgh, Pa.

PUGET SOUND SECTION

Associate Member:
Gleason, D. S., 901 E. 45th St., Seattle 5, Wash.

QUEBEC CHAPTER

Associate Member:
Blackburn, Henry, Bedard-Girard Ltee., Quebec, Que.

ROCHESTER CHAPTER

Member:
Cherne, R. E., 311 Alexander St., Rochester, N. Y.

Associate Members:
Driscoll, D. R., E. E. Driscoll & Son Electric Co., Rochester, N. Y.
Erskine, D., Erskine-Healy, Inc., Rochester, N. Y.
Hill, H. G., Sylvania Electric Products Inc., Buffalo, N. Y.
Holcomb, F. B., Jr., General Electric Supply Corp., Rochester, N. Y.
Horacek, Louis, Horacek-Hayden Inc., Rochester, N. Y.
Muldoon, J. M., Westinghouse Electric Supply Co., Rochester, N. Y.
Nolan, H. G., Industrial Electric Co., Inc., Rochester, N. Y.

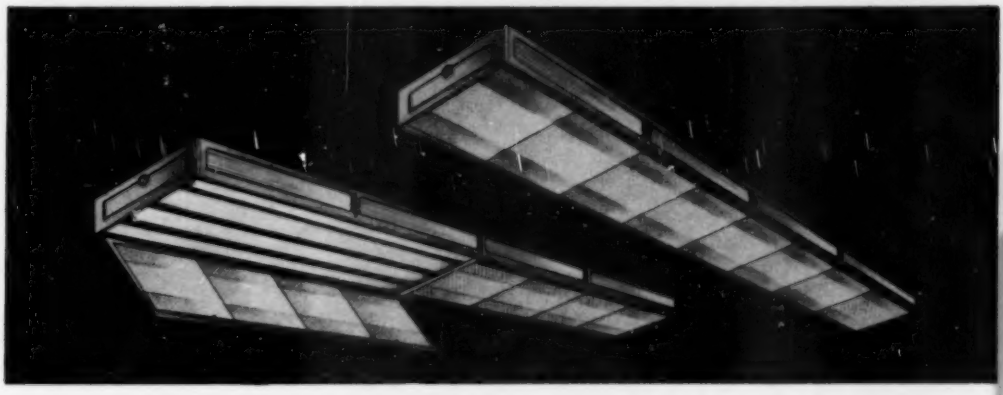
ROCKY MOUNTAIN SECTION

Members:
Bazant, S., Jr., Public Service Co. of New Mexico, Albuquerque, N. M.
Albach, C. R., 1526 Cochiti St., Santa Fe, N. M.

Associate Members:
Ford, Dean Q., Weers Electrical Planning Service, Denver, Colo.
Langdon, L. R., Southern Colorado Power Co., Pueblo, Colo.
Mills, E. P., Public Service Co. of Colo., Denver, Colo.
Parker, J. E., Southern Colorado Power Co., Pueblo, Colo.
Pond, Ray E., Ray E. Pond Electric Co., Santa Fe, N. M.

(Continued on page 46A)

NOW! PLEXOLINE® FLEXIBILITY WITH NEW LOW BRIGHTNESS

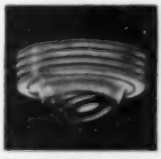


HINGED LENS PLEXOLINE®

The introduction of Day-Brite's Plexoline system in 1950 made headline news in the lighting industry.

Now Day-Brite announces a new Plexoline development to meet the increasing demand for low brightness luminaires.

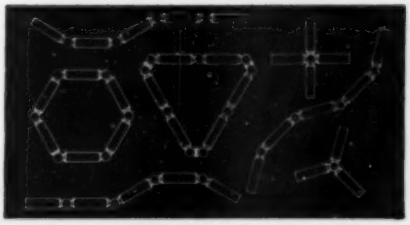
The new HINGED LENS PLEXOLINE is a 2-lamp fixture, equipped with Holophane Controlens* No. 9015, fitted into a hinged frame. A separable hinging arrangement allows hinging from either side or complete removal for easy maintenance.



Plexoline Circular Units—Adjustable and fixed accent units with luminous sides.

Available in eight-foot and four-foot sections for Slimline or Fluorescent lamps, the HINGED LENS PLEXOLINE is recommended for surface mounting only and top reflector plates are furnished for 100% direct distribution of light.

*Ⓡ Holophane Company



HINGED LENS PLEXOLINE is a new addition to the famous Plexoline system. Combined with Plexoline-2 circular units and adapters, this new linear unit permits unlimited lighting patterns—curves, circles, angular patterns, abstract designs—with the most advanced low brightness qualities.

All Plexoline linear sections are equipped with ribbed glass side panels of Albalite glass, which has a low surface brightness and high light transmission properties.

Full information and data on the new HINGED LENS PLEXOLINE are available on request. Write today to the address below.

223

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(Continued from page 44A)

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Chaudoin, M. H., Graybar Electric Co. Inc., St. Louis, Mo.

Irwin, E. E., Lighting Service Inc., St. Louis, Mo.

SAN JACINTO SECTION

Associate Members:

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Poskey, A. D., Jr., Graybar Electric Co., Houston, Texas.

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SOUTHERN CALIFORNIA SECTION

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Associate Members:

Gruen, William, Gruen Lighting Co., Los Angeles, Calif.

Holston, R. W., Pryne & Co., Inc., Pomona, Calif.

Ryan, R. H., Southern Calif. Edison Co., Visalia, Calif.

Shoolbred, C. E., Fluorescent Fixtures of Calif., Los Angeles, Calif.

Turpin, C. E., Hilburg & Hengstler, Los Angeles, Calif.

Weiner, M. A., Fluorescent Fixtures of Calif., Los Angeles, Calif.

SOUTHWESTERN SECTION

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Peak, Preston, Gill Glass & Fixture Co., Dallas, Texas.

Roach, L. W., Electrical Supply Corp., Dallas, Texas.

Weiss, J. D., Electrical & Mechanical Supply Co. Inc., El Paso, Texas.

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Associate Members:

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Munding, W. A., Day-Brite Lighting, Memphis, Tenn.

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Bodan, B. P., Southern College of Optometry, Memphis, Tenn.

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Sjorgren, F. A., Graybar Electric Co., Duluth, Minn.

Thometz, W. M., Northern States Power Co., St. Cloud, Minn.

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Damberg, J. P., University of Minnesota, Minneapolis, Minn.

Foster, J. W., 248 S. Oak St., Neillsville, Wis.

Freerks, G. L., University of Minnesota, Minneapolis, Minn.

Lenci, R. K., University of Minnesota, Minneapolis, Minn.

Williams, L. J., University of Minnesota, Minneapolis, Minn.

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Pfalzgraf, F. R., Thrift Lamp Co., Buffalo, N. Y.

WINNIPEG CHAPTER

Associate Member:

McKenzie, R. B., McKenzie Electric Ltd., Lethbridge, Alb.

Local Representatives

(Continued from page 38A)

Winston-Salem, N. C. — M. C. Baldwin, Duke Power Company.
Winter Park, Fla. — Russell W. Raine, Russell Raine & Associates.

South Pacific Coast Region

Boise, Idaho — Kenneth R. Jones, General Electric Supply Co.
Fresno, Calif. — Frank E. Leino, McDougald & Leino.
Ogden, Utah — Henry D. Phillips, Utah Power & Light Co.
Provo, Utah — Douglas Peck, Peck Electric Co.
Prescott, Ariz. — George A. Hill, P. O. Box 391.
Reno, Nev. — Walter J. Herz, Sierra Pacific Power Co.
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San Diego, Calif. — Carlton M. Thompson, San Diego Gas & Electric Co.
San Jose, Calif. — William Addison, Pacific Gas & Electric Co.
San Rafael, Calif. — James E. Barnes, Pacific Gas & Electric Co.
Santa Barbara, Calif. — Harry V. Dobson, City of Santa Barbara.
Tucson, Ariz. — George W. Gerlach, 830 North Euclid Avenue.

Southwestern Region

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Amarillo, Texas — Thomas J. Lynn, Southwestern Public Service Co.
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Cheyenne, Wyo. — W. B. Ptech, Cheyenne Light, Fuel & Power Co.
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Grand Junction, Colo. — Shirley W. Huntsman.
Greeley, Colo. — Charles G. Dresser, Home Gas & Electric Company.
Little Rock, Ark. — E. G. Barry, Arkansas Power & Light Co.
Pueblo, Colo. — Charles D. Bell, 1942 Palmer Avenue.
Rapid City, S. D. — F. W. Woosley.
Santa Fe, N. M. — Carl R. Albach, 1526 Chochiti St.
Scottsbluff, Nebr. — C. L. Kelly.
Shreveport, La. — R. K. Lothrop, Southwestern Gas & Electric Co.
Oklahoma City, Okla. — J. Dale Hampton, Oklahoma Gas & Electric Co.
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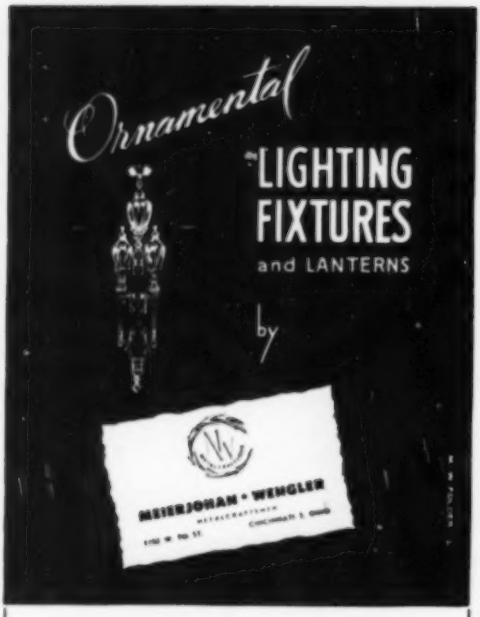

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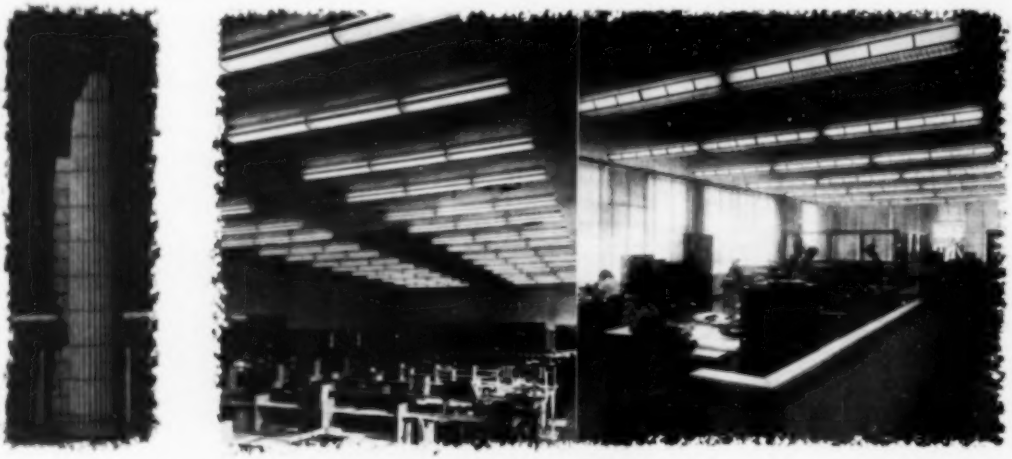

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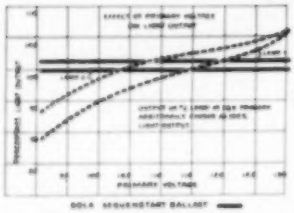
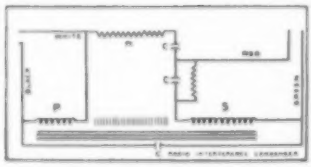


CONSTANT WATTAGE OUTPUT

Cut-A-Way View—

VENTILATED CAPACITOR COMPARTMENT

Typical Schematic



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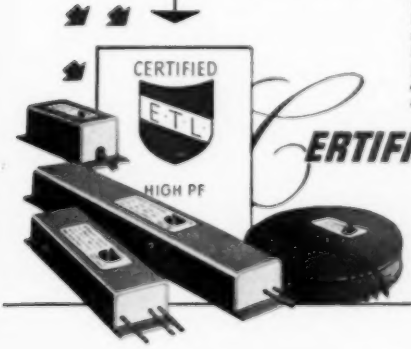

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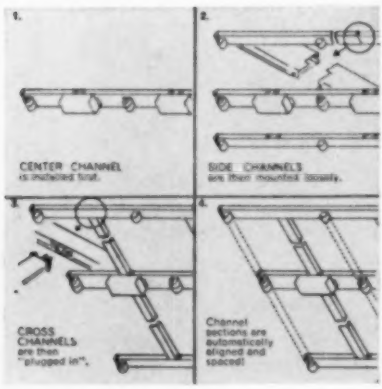

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